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THE PROBLEM OF CONSCIOUSNESS IN ITS BIOLOGICAL ASPECTS.*

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OUR Association meets in Pittsburgh for the first time. We are glad to indicate by our assembling here our appreciation of the immense work for the promotion of education and science which has begun in this city and already is of national value. It has been initiated with so great wisdom and zeal that we expect it to render services to knowledge of the highest character, and we are glad to be guests of a city and of institutions which are contributing so nobly to the cause of science.

We may congratulate ourselves on the bright prospects of the Association. Our membership has grown rapidly, and ought soon to exceed four thousand. Every member should endeavor to secure new adherents. For our next meeting we are to break with the long tradition of summer gatherings and assemble instead at New Year's time, presumably at Washington. To render this possible it was necessary to secure the cooperation of our universities, colleges and technical schools, to set aside the week in which the first of January falls, as *Convocation Week,* for the meeting of learned societies. The plan, owing to the cordial and almost universal support given by the higher educational institutions, has been successfully carried through. For the winter meetings we have further succeeded in securing the cooperation of numerous national societies. The change in our time of meeting is an

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experiment which we venture upon with the greater confidence, because of the success of our present meeting in Pittsburgh.

For my address this evening I have chosen the theme: 'The Problem of Consciousness in its Biological Aspects.' I hope both to convince you that the time has come to take up consciousness as a strictly biological problem, and also to indicate the nature of that problem, and some of the actual opportunities for investigating it. It is necessary to begin with a few words on the philosophical interpretation. We shall then describe the function of consciousness in animal life, and consider its part in the evolution of animals and of man. The views to be stated suggest certain practical recommendations, after presenting which I shall conclude by offering an hypothesis of the relation of consciousness to matter and force.

Consciousness is at once the oldest problem of philosophy and one of the youngest problems of science. The time is not yet for giving a satisfactory definition of consciousness, and we must fain content ourselves with the decision of the metaphysician, who postulates consciousness as an ultimate datum or concept of thought, making the brief dictum *cogito, ergo sum* the pivot about which his system revolves. I have endeavored vainly to discover by reading and by questioning those philosophers and psychologists whom I know, some deeper analysis of consciousness, if possible, resolving it into something more ultimate.

Opinions concerning consciousness are many and often so diverse as to be mutually exclusive, but they may be divided into two principal classes. The first class includes all those views which make of consciousness a real phenomenon; the second, those views which interpret it as an epiphenomenon. We are, I think practically all, agreed that the fundamental question is: Does or does not consciousness affect directly the course of events?—or, stated in other words, is consciousness a true cause? In short, we encounter at the outset the problem of free-will; of which more later.

The opinion that consciousness is an epiphenomenon has gained renewed prominence in recent times, for it is, so to speak, a collateral result of that great movement of European thought which has culminated in the development of the doctrine of monism. Monism itself is postulated chiefly upon the two greatest discoveries of the nineteenth century—the law of the conservation of energy, and the law of the evolution of species. Both laws establish a greater unity in the phenomena of the universe than mankind had previously been able to accept. In the physical world, instead of many forces, we now recognize only one force, which assumes various forms of energy; and in the living world we recognize one life, which manifests itself in many types of form. With these two unities in mind, what could be nearer than the thought that the unity goes still deeper, and that the phe-

nomena of the inanimate or physical, and of the living world are fundamentally identical? The progress of physiological science has greatly increased the impetus towards the adoption of this thought as the cardinal dogma of the new faith, because the work of physiologists has been so devoted to the physical and chemical phenomena of life, that the conviction is widespread that all vital phenomena are capable of a physical explanation. Assuming that conviction to be correct, it is easy to draw the final conclusion that the physical explanation suffices for the entire universe. As to what is, or may be, behind the physical explanation, complete agnosticism is of course the only possible attitude. Such in barest—but I believe correct—outline is the history of modern monism—the doctrine that there is but one kind of power in the universe.

It is evident that monism involves the elimination of two concepts, God and consciousness. It is true that monists sometimes use these words, but it is mere jugglery, for they deny the concept for which the words actually stand. Now, consciousness is too familiar to all men to be summarily cast aside and dismissed. Some way must be found to account for it. From the monistic standpoint there is a choice between two possible alternatives; either consciousness is a form of energy, like heat, etc., or it is merely a so-called epiphenomenon. As there is no evidence that consciousness is a form of energy, only the second alternative is in reality available, and in fact has been adopted by the monists.

It is essential to have a clear notion of what is meant by an epiphenomenon. Etymologically the word indicates something which is superimposed upon the actual phenomenon. It designates an accompanying incident of a process which is assumed to have no causal relation to the further development of the process. In practice it is used chiefly in regard to the relation of the mind or consciousness to the body, and is commonly employed by those philosophers who believe that consciousness has no causal relation to any subsequent physiological process.

For many years I have tried to recognize some actual idea underneath the epiphenomenon hypothesis of consciousness, but it more and more seems clear to me that there is no idea at all, and that the hypothesis is an empty phrase, a subterfuge, which really amounts only to this—we can explain consciousness very easily by merely assuming that it does not require to be explained at all. Is not that really the confession made by the famous assertion that the consciousness of the brain no more requires explanation than the aquosity of water?

Monism is not a strong system of philosophy, for it is not so much the product of deep and original thinking as the result of a contemporary tendency. It is not the inevitable end of a logical process, because it omits consciousness, but rather an incidental result of an

intellectual impulse. Its very popularity betokens its lack of profundity, and its delight in simple formulæ is characteristic of that mediocrity of thought which has much more ambition than real power and accepts simplicity of formularization as equivalent to evidence. It would seem stronger too, if it were less defended as a faith. Strong partizans make feeble philosophers.

Consciousness ought to be regarded as a biological phenomenon, which the biologist has to investigate in order to increase the number of verifiable data concerning it. In that way, rather than by speculative thought, is the problem of consciousness to be solved, and it is precisely because biologists are beginning to study consciousness that it is becoming, as I said in opening, the newest problem of science.

The biologist must necessarily become more and more the supreme arbiter of all science and philosophy, for human knowledge is itself a biological function which will become comprehensible just in the measure that biology progresses and brings knowledge of man, both by himself and through comparison with all other living things. We must look to biologists for the mighty generalizations to come rather than to the philosophers, because great new thoughts are generated more by the accumulation of observations than by deep meditation. To know, observe. Observe more and more, and in the end you will know. A generalization is a mountain of observations; from the summit the outlook is broad. The great observer climbs to the outlook, while the mere thinker struggles to imagine it. The best that can be achieved by sheer thinking on the data of ordinary human experience we have already as our glorious inheritance. The principal contribution of science to human progress is the recognition of the value of accumulating data which are found outside of human experience.

Twenty-three years ago, at Saratoga, I presented before the meeting of this Association—which I then attended for the first time—a paper, 'On the Conditions to be filled by a Theory of Life,' in which I maintained that, before we can form a theory of life, we must settle what are the phenomena to be explained by it. So now, in regard to consciousness it may be maintained that, for the present, it is more important to seek additional positive knowledge than to hunt for ultimate interpretations. We welcome therefore especially the younger science of experimental psychology, which, it is gratifying to note, has made a more auspicious start in America than in any other country. It completes the circle of the biological sciences. It is the department of biology to which properly belongs the problem of consciousness. The results of experimental psychology are still for the most part future. But I shall endeavor to show that we may obtain some valuable preliminary notions concerning consciousness from our present biological knowledge.

We must begin by accepting the direct evidence of our own consciousness as furnishing the basis. We must further accept the evidence that consciousness exists in other men essentially identical with the consciousness in each of us. The anatomical, physiological and psychological evidence of the identity of the phenomena in different human individuals is, to a scientific mind, absolutely conclusive, even though we continue to admit cheerfully that the epistemologist rightly asserts that no knowledge is absolute, and that the metaphysician rightly claims that *ego* is the only reality and everything else exists only as *ego's* idea, because in science as in practical life we assume that our knowledge is real and is objective in source.

For the purpose of the following discussion we must define certain qualities or characteristics of consciousness. The most striking distinction of the processes in living bodies, as compared with those in inanimate bodies, is that the living processes have an object—they are teleological. The distinction is so conspicuous that the biologists can very often say *why* a given structure exists, or *why* a given function is performed, but *how* the structure exists or *how* the function is performed he can tell very imperfectly, more often not at all. Consciousness is only a particular example, though an excellent one, of this peculiarity of biological knowledge—we do not know what it is, we do not know how it functions, but we do know why it exists. Those who are baffled by the elusiveness of consciousness when we attempt to analyze it will do well to remember that all other vital phenomena are in the last instance equally and similarly elusive.

In order to determine the teleological value of consciousness, we must endeavor to make clear to ourselves what the essential function is which it performs. As I have found no description or statement of that function which satisfied me, I have ventured, perhaps rashly, to draw up the following new description:

The function of consciousness is to dislocate in time the reactions from sensations.

In one sense this may be called a definition of consciousness, but inasmuch as it does not tell what consciousness is, but only what it does, we have not a true definition, but a description of a function. The description itself calls for a brief explanation. We receive constantly numerous sensations, and in response to these we do many things. These doings are, comprehensively speaking, our reactions to our sensations. When the response to a stimulus is obviously direct and immediate we call the response a reflex action, but a very large share of our actions are not reflex but are determined in a far more complicated manner by the intervention of consciousness, which may do one of two things: (1) Stop a reaction, as, for example, when something occurs, calling, as it were, for our attention and we do not give our

attention to it. This we call conscious inhibition. It plays a great rôle in our lives; but it does not mean necessarily that inhibited impressions may not survive in memory and at a later time determine the action taken; in such cases the potential reaction is stored up. (2) Consciousness may evoke a reaction from a remembered sensation and combine it with sensations received at other times. In other words, consciousness has a selective power, manifest both in choosing from sensations received at the same time and in combining sensations received at different times. It can make synchronous impressions dyschronous in their effects, and dyschronous impressions synchronous. But this somewhat formidable sentence merely paraphrases our original description: The function of consciousness is to dislocate in time the reactions from sensations.

This disarrangement and constant rearrangement of the sensations, or impressions from sensations, which we gather, so that their connections in time are altered seems to me the most fundamental and essential characteristic of consciousness which we know. It is not improbable that hereafter it will become possible to give a better characterization of consciousness. In that case the opinion just given may become unsatisfactory, and have to yield to one based on greater knowledge. The characteristic we are considering is certainly important, and so far as the available evidence goes it belongs exclusively to consciousness. Without it life would have no interest, for there would be no possibility of experience, no possibility of education.

Now, the more we have learned about animals, the better have we appreciated the fact that in them only such structures and functions are preserved as are useful, or have a teleological value. Formerly a good many organs were called rudimentary or vestigial and supposed to be useless survivals because they had no known function. But in many cases the functions have since been discovered. Such, for example, were the pineal gland, the pituitary body, the suprarenal capsules and the Wolffian body of man, all of which are now recognized to be functionally important structures. Useless structures are so rare that one questions whether any exist at all, except on an almost insignificant scale. It has accordingly become well-nigh impossible for us to imagine consciousness to have been evolved, as it has been, unless it had been bionomically useful. Let us therefore next consider the value of consciousness from the standpoint of bionomics.*

We must begin with a consideration of the nature of sensations and the object of the reactions which they cause. In the simpler forms of nervous action a force, usually but not necessarily external to the

* A convenient term, recently gaining favor, for what might otherwise be called the economics of the living organism. Bionomics seems preferable to *ecology*, which some writers are adopting from the German.

organism, acts as a stimulus which causes an irritation; the irritation produces a reaction. Within the ordinary range of the stimuli to which an organism is subjected, the reaction is teleological, that is, it tends to the benefit of the organism. A familiar illustration is the presence of food in the stomach, which produces a stimulus, the reaction to which is manifested by the secretion of the digestive fluid for the purpose of digesting the food. An organism might conceivably be maintained solely by this mechanism in cooperation with the physical laws which govern all matter. Life in such an organism would be a succession of teleological processes, essentially mechanical and regulated automatically by the organism. By far the majority of biologists regard plants as essentially conforming to this type of life. Whether they absolutely so conform we do not, of course, yet know.

A sensation involves the interpolation of consciousness between the stimulation and the reaction, and in consequence there is established the possibility of a higher order of adjustment to the external world than can be attained through the teleological reaction to a stimulus. This possibility depends upon the fact that the intervention of consciousness permits an adjustment in accordance not merely with the immediate sensation, but also, and at the same time, in accordance with earlier sensations. Thus, for example, the child sees an object, and its reaction is to take hold of the object, which is hot and hurts the child. Later the child sees the object again and its natural reaction is to take hold of it again, but the child now reacts differently because its consciousness utilizes the earlier as well as the present sensation; the previous sensation is dislocated in time and fused with the present sensation and a new reaction follows. No argument is necessary to establish the obvious conclusion that an organism which has consciousness has an immensely increased scope for its adjustments to the external conditions; in other words, consciousness has a very high value for the organism. It is unnecessary to dwell upon this conclusion, for it will be admitted by every one, except perhaps those who start with the *a priori* conviction that consciousness is an epiphenomenon.

A sensation gives information concerning the external world. Perhaps science has achieved nothing else which has done so much to clarify philosophy as the demonstration that the objective phenomena are wholly unlike the subjective sensations. Light is a series of undulations, but we do not perceive the undulation as such, but as red, yellow and green, or as we say colors; the colors give us available information, and we use them as so many labels, and we learn that reactions to these labels may be helpful or hurtful, and so we regulate our conduct. Objectively red, yellow and green do not exist. Similarly with the vibrations of the air, certain of which cause the sensation of sound, which is purely subjective. But the sound gives us information con-

cerning our surroundings, which we utilize for our teleological needs, although in nature external to us there is no sound at all. Similarly all our other senses report to us circumstances and conditions, but always the report is unlike the external reality. Our sensations are symbols merely, not images. They are, however, bionomically sufficient because they are constant. They are useful not because they copy the external reality or represent it, but because, being constant results of external causes, they enable consciousness to prophesy or foresee the results of the reactions of the organism, and to maintain and improve the continual adjustment to the external reality.

The metaphysicians have for centuries debated whether there is any external objective reality. Is it too much to say that the biological study of consciousness settles the debate in favor of the view that the objective world is real?

Consciousness is not only screened from the objective world from which it receives all its sensations, but also equally from immediate knowledge of the body through which it acts. As I write this sentence I utilize vaso-motor nerves, regulating the cerebral blood currents, and other nerves which make my hand muscles contract and relax, but of all this physiological work my consciousness knows nothing though it commands the work to be done. The contents of consciousness are as unlike what is borne out from it as they are unlike what is borne in to it.

The peculiar untruthfulness to the objective which consciousness exhibits in what it gets and gives would be perplexing were it not that we have learned to recognize in consciousness a device to secure better adjustment to external reality. For this service the system of symbols is successful, and we have no ground for supposing that the service would be better if consciousness possessed direct images or copies instead of symbols of the objective world.

Our sensory and motor* organs are the servants of consciousness; its messengers or scouts; its agents or laborers; and the nervous system is its administrative office. A large part of our anatomical characteristics exists for the purpose of increasing the resources of consciousness, so that it may do its bionomic function with greater efficiency. Our eyes, ears, taste, etc., are valuable, because they supply consciousness with data; our nerves, muscles, bones, etc., are valuable, because they enable consciousness to effect the needed reactions.

Let us now turn our attention to the problem of consciousness in animals. The comparative method has an importance in biology which it has in no other science, for life exists in many forms which we commonly call species. Species, as I once heard it stated, differ from one

* And other organs in efferent relations to consciousness.

another with resemblance. The difference which resembles we term an homology. Our arm, the bird's wing, the lizard's front leg are homologous. The conception of homology both of structure and of function lies at the basis of all biological science, which must be and remain incomprehensible to any mind not thoroughly imbued with this conception. Only those who are deficient in this respect can fail to understand that the evidence is overwhelming that animals have a consciousness homologous with the human consciousness. The proof is conclusive. As regards at least mammals—I think we could safely say as regards vertebrates—the proof is the whole sum of our knowledge of the structure, functions and life of these animals.

As we descend the animal scale to lower forms there is no break and therefore no point in the descent where we can say here animal consciousness ends, and animals below are without it. It seems inevitable therefore to admit that consciousness extends far down through the animal kingdom, certainly at least as far down as there are animals with sense organs or even the most rudimentary nervous system. It is unsatisfactory to rely chiefly on the anatomical evidence for the answer to our query. We await eagerly results from psychological experiments on the lower invertebrates. A sense organ however implies consciousness, and since such organs occur among cœlenterates we are led to assign consciousness to these animals.

The series of considerations which we have had before us lead directly to the conclusion that the development and improvement of consciousness has been the most important, really the dominant, factor in the evolution of the animal series. The sense organs have been multiplied and perfected in order to supply consciousness with a richer, more varied and more trustworthy store of symbols corresponding to external conditions. The nervous system has grown vastly in complexity in order to permit a constantly increasing variety in the time dislocations of sensation. The motor and allied apparatus have been multiplied and perfected in order to supply consciousness with more possibilities of adjustment to external reality which might be advantageous.

If we thus assign to consciousness the leading rôle in animal evolution we must supplement our hypothesis by another, namely, that conscious actions are primary; reflex and instinctive actions secondary, or, in other words, that, for the benefit of the organism, conscious actions have been transformed into reflexes and instincts. Unfortunately we must rely chiefly on future physiological and psychological experiments to determine the truth of this hypothesis. Its verification, however, is suggested by certain facts in the comparative physiology of the vertebrate nervous system, which tend to show that in the lower forms (amphibia) a certain degree of consciousness presides over the

functions of the spinal cord, which in mammals is devoted to reflex actions. Its verification is further suggested by the natural history of habits. As we all know, new actions are performed with difficulty and slowly, but if often repeated they are soon easier and more rapid. If a given reaction to a sensation or group of sensations through consciousness is advantageous to the organism and the environment is such that the sensation is often repeated, then a habit is formed and the response becomes more rapid, and often in ourselves we see habits which arose from conscious action working almost without the participation of consciousness, and moreover working usefully because rapidly. The usefulness of conscious reactions is that they are determined not merely by the present sensation but also by past sensations, but they have the defect that they are slow. We can readily understand that it would aid an organism to have the quicker reaction substituted, and we thus recognize a valid teleological reason for the replacement of conscious action by habits in the individual, by instincts in the race. The investigation of the evolution of reflexes and instincts is one of the important and most promising tasks of comparative psychology.

A frank unbiased study of consciousness must convince every biologist that it is one of the fundamental phenomena of at least animal life, if not, as is quite possible, of all life. Nevertheless its consideration has barely a place in biological science, although it has long occupied a vast place in philosophy and metaphysics. If this address shall contribute to a clearer appreciation of the necessity of treating consciousness as primarily a problem for biological research to solve, my purpose will be achieved. In an ideal world philosophers and scientists would be identical; in the actual world there are philosophical scientists and scientific philosophers, but in the main the followers of the two disciplines pursue paths which are unfortunately distinct. The philosophical mind is of a type unlike the scientific. The former tries to progress primarily by thought based on the data available, the latter seeks to advance primarily by collecting additional data. The consequence of this difference is that philosophy is dependent upon the progress of science, but we who pursue the scientific way make no greater mistake than to underestimate philosophy. The warning is needed. Data of observation are a treasure and very precious. They are the foundation of our mental wealth, but that wealth consists of the thought into which the data are transmitted. In pleading therefore for an increased observational study of consciousness we plead, not merely for science, but equally for philosophy. The scientific progress must come first. Hence we urge the advantage of investigating consciousness in its immediate revelations which are accessible now. Let us give up the ineffectual struggle to discover the essential nature

of consciousness until we can renew it with much larger resources of knowledge.

The psychologists ought now to apply the comparative method on a grand scale. They are just beginning to use it. Years of patient labor must pass by, but the reward will be very great. The psychic life of animals must be minutely observed, the conditions of observation carefully regulated and the results recorded item by item. The time has passed by for making generalizations on the basis of our common, vague and often inexact notions concerning the habits of animals. Exact experimental evidence will furnish a rich crop of psychological discovery. Scientific psychology is the most backward in its development of all the great divisions of biology. It needs, however, little courage to prophesy that it will bring forth results of momentous importance to mankind. After data have been gathered, generalization will follow which, it may be hoped, will lead us on to the understanding of even consciousness itself.

The teleological impress is stamped on all life. Vital functions have a purpose. The purpose is always the maintenance of the individual or of the race in its environment. The entire evolution of plants and animals is essentially the evolution of the means of adjustment of the organism to external conditions. According to the views I have laid before you, consciousness is a conspicuous, a commanding, factor of adjustment in animals. Its superiority is so great that it has been, so to speak, eagerly seized upon by natural selection and provided with constantly improved instruments to work with. A concrete illustration will render the conception clearer. In the lowest animals, the cœlenterates, in which we can recognize sense organs, the structure of them is very simple, and they serve as organs of touch and of chemical sensation resembling taste. In certain jelly fishes we find added special organs of orientation and pigmented spots for the perception of light. In worms we have true eyes and vision. In vertebrates we encounter true sense of smell. Fishes cannot hear, but in the higher vertebrates, that is from the amphibians up, there are true auditory organs. In short, both the senses once evolved are improved and also new senses are added. It is perfectly conceivable that there should be yet other senses, radically different from any we know. Another illustration, and equally forcible, of the evolution of aids to consciousness might be drawn from the comparative history of the motor systems, passing from the simple contractile thread to the striated muscle fiber, from the primitive diffuse musculature of a hydroid to the highly specialized and correlated muscles of a mammal.

It is interesting to consider the evolution of adjustment to external reality in its broadest features. In the lowest animals the range of the possible adjustment is very limited. In them not only is the variety

of possible actions small, but they cover also a small period of time. In animals which have acquired a higher organization the adjustments are more complex, both because the reactions are more varied and because they cover a longer period of time. Thus the jelly fish depends upon such food as happens to come within its reach, seizing from moment to moment that which it encounters; but a lobster pursues its food, making complicated movements in order to reach and seize it. One can trap lobsters easily; I doubt if one could trap a jelly fish at all. The next great advance is marked by the establishment of communication between individuals of the same species. About this phenomenon we know exceedingly little; the investigation of it is one of the most important duties of the comparative physiologist. Its bionomic value is obviously great, for it allows an individual to utilize the experience of another as well as its own. We might, indeed, compare it with the addition of a new sense, so greatly does it extend the sources of information. The communication between individuals is especially characteristic of vertebrates, and in the higher members of that subkingdom it plays a very great rôle in aiding the work of consciousness. In man, owing to articulate speech, the factor of communication has acquired a maximum importance. The value of language, our principal medium of communication, lies in its aiding the adjustment of the individual and the race to external reality. Human evolution is the continuation of animal evolution, and in both the dominant factor has been the increase of the resources available for consciousness.

In practical life it is convenient to distinguish the works of nature from the works of man, the 'natural' from the 'artificial.' The biologist, on the contrary, must never allow himself to forget that man is a part of nature and that all his works are natural works. This is specially important for the present discussion, for otherwise we are likely to forget also that man is as completely subject to the necessity of adjustment to external reality as any other organism. From the biological standpoint all the work of agriculture, of manufactures, of commerce and of government is a part of the work of consciousness to secure the needed adjustments. All science belongs in the same category as the teleological efforts of a jelly fish or a lobster. It is work done at the command of consciousness to satisfy the needs of existence. The lesson of all this to us is that we should accustom ourselves to profit by our understanding of the trend of evolution, which, in the progress humanity makes, obeys the same law of adaptation to objective reality which has controlled the history of animals. This view of the conditions of our existence puts science in its right place. As all sensations are symbols of external reality useful to guide organisms to teleological reactions, so is all science symbolic and similarly useful.

Nature never produces what to us seems a perfect organism, but only organisms which are provided with means of adjustment sufficient to accomplish the survival and perpetuation of the species. Man also is imperfect, but in the struggle for existence wins his way because his consciousness has greater resources than that of any other organism. His great power arises from his appreciation of evolution. His highest duty is to advance evolution, and this duty must be most strongly felt by those who accept the religious interpretation of life. The advancement of science is an obligation. To this view of the work of our Association I may safely claim the assent of all present.

The function of science is to extend our acquaintance with the objective world. The purpose of the American Association is not alone to increase the sum total of science, but equally also to preach by word and precept the value of truth, truth being the correct conscious symbol of the objective, by utilizing which our purposeful reactions are improved. The most serious obstacle truth encounters is the prevalence of what I may call 'doll ideas'—by analogy with the material dolls, with which children play. The child makes believe with the doll, knowing all the time its unreality, assigns to it hopes, passions, appetites; the child may feel the intensest sympathy with its doll, weep at its sorrows, laugh over its joys, yet know always that it is a mere inanimate, senseless doll. Adult men and women have ideas, with which they play make-believe; doll ideas, which they know are unreal, and yet they mourn sincerely over the adversities of their mental dolls, rejoice over their successes and fight for them with passion. Such doll ideas become mingled with the real and inextricably woven into the fabric of life. They are treated with the most earnest seriousness. Men will fight for them as a child will fight for its doll, not because it is property, but because it is a sacred personality. So are doll ideas often made sacred and defended with fanaticism. Yet, behind, in consciousness is the sense of unreality, the disregarded admission of 'making believe.' Do not doll ideas, pseudo-opinions, play a great rôle in human life? I think they do, and thinking so, deem it all the more imperative that you and others should teach the people the standard of science, the humble acknowledgment of reality. I wish that an impulse toward this goal from our Association could be imparted to every man and woman in the country, and I hope that the Association may continue to grow in number and power for long years to come, as it has grown in the last few years, so that it shall be a national, all-pervading influence serving the truth.

It seems to me inconceivable that the evolution of animals should have taken place as it actually has taken place, unless consciousness is a real factor and dominant. Accordingly I hold that it actually affects the vital processes. There is, in my opinion, no possibility of avoiding

the conclusion that consciousness stands in immediate causal relations with physiological processes. To say this is to abide by the facts, as at present known to us, and with the facts our conceptions must be made to accord.

The thought which I wish to emphasize is the importance for the future investigation of consciousness of separating the study of what it does from the study of what it is. The latter study is recondite, metaphysical, and carries us far beyond the limits of verifiable human knowledge. The former study is open to us and offers opportunities to science, but it has hitherto been almost completely neglected. Biology has now to redeem itself by effectual researches on consciousness. On the adequate prosecution of such researches we base great hopes.

Before I close permit me a few words concerning the relations of consciousness to the body, to living substances through which it manifests itself. It is intimately linked to protoplasm. Probably no question is so profoundly interesting to all mankind as the old question, what is the relation of the mind to the body? It is a question which has been stated in many forms and from many points of view, but the essential object of the question is always the same, to ask whether consciousness is a function of living matter, or something discrete and not physical or material.

Throughout this address consciousness has been viewed as a device to regulate the actions of the organisms so as to accomplish purposes which on the whole are useful to the organisms, and accordingly we have termed its function teleological. If this view is correct it accounts for the limitations of consciousness, its mechanical mode of work, its precision and definiteness of action, for of course, unless consciousness is orderly and obeys laws, it cannot be of use to the organism, but, on the contrary, it would be harmful, and conscious animals would have ceased long ago to survive. The very fact that consciousness is of such high value in the bionomy of an animal renders it obvious that it must be subject to law. Accordingly it appears to us regulated as do the functions of protoplasm. Hence to certain modern thinkers it presents itself as a function of protoplasm, or, as it may be better stated, as a state or condition of protoplasm.

The internal evidence of consciousness, however, is against this view and presents to us conscious actions as depending upon the consciousness. As before stated I believe that this evidence must be accepted. Now all the sensations of consciousness are derived from physical force, and all the acts of consciousness are manifested through physical force; hence if it has any real power consciousness must be able to change the form of energy. Unless we accept this doctrine, we must give up all belief in free-will and adopt the automaton theory of life. Is not the more reasonable explanation that which is based upon

all the contents of our consciousness rather than that which we can draw by discarding the internal evidence which consciousness brings us? The hypothesis which I offer for your consideration is this:

Consciousness has the power to change the form of energy, and is neither a form of energy nor a state of protoplasm.

By this hypothesis there are two fundamentally different things in the universe, force and consciousness. You ask why I do not say three, and add matter? My answer is that we do not have, and never have had, any evidence whatever that matter exists. All our sensations are caused by force and by force only, so that the biologist can say that our senses bring no evidence of matter. The concept 'matter' is an irrational transfer of notions derived from the gross molar world of the senses to the molecular world. Faraday long ago pointed out that nothing was gained and much lost by the hypothesis of material atoms, and his position seems to me impregnable. It would be a great contribution to science to kill off the hypothesis of matter as distinct from force.

To conclude: The universe consists of force and consciousness. As consciousness by our hypothesis can initiate the change of the form of energy, it may be that without consciousness the universe would come to absolute rest. Since I close with a bold speculation let my last words recall to you that my text is: Investigate consciousness by comparative observations. Only from observation can we know. Correct, intelligent, exhaustive observation is our goal. When we reach it human science will be completed.

THE PANAMA ROUTE FOR A SHIP CANAL. II.

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THE total length of the Panama route from the six-fathom curve at Colon to the same curve in Panama Bay is 49.09 miles. The general direction of the route in passing from Colon to Panama is from northwest to southeast, the latter point being about 22 miles east of the Atlantic terminus. The depression through which the line is laid is one of easy topography except at the continental divide in the Culebra cut. As a consequence there is little heavy work of excavation, as such matters go, except in that cut. A further consequence of such topography is a comparatively easy alignment, that is one in which the amount of curvature is not high. The smallest radius of curvature is 3,281 ft. at the entrance to the inner harbor at the Colon end of the route, and where the width is 800 ft. The radii of the remaining curve range from 6,234 ft. to 19,629 ft.

The following table gives all the elements of curvature on the route and indicates that it is not excessive:

Number of Curves.	Length.	Radius.	Total Curvature.
	Miles.	Feet.	° ′
1	0.88	19,629	14 17
1	.48	13,123	11 04
4	4.22	11,483	111 32
15	11.61	9,842	355 50
4	2.44	8,202	90 20
2	1.67	6,562	77 00
1	.73	6,234	35 45
1	.82	3,281	75 51
	22.85		771 39

Throughout the most of the distance between Colon and Bohio on the easterly side of the canal, the French plan contemplated an excavated channel to receive a portion of the waters of the Chagres as well as the flow of two smaller rivers, the Gatuncillo and the Mindi, so as to conduct them into the bay of Manzanillo, immediately to the east of Colon. That so-called diversion channel was nearly completed. Under the plan of the commission it would receive none of the Chagres flow, but it would be available for intercepting the drainage of the high ground easterly of the canal line and the flow of the two small rivers

named, so that those waters would not find their way into the canal. There are a few other small works of similar character in different portions of the line, all of which were recognized and provided for by the commission.

The principal items of the total amount of work to be performed in completing the Panama canal, under the plan of the commission, can be classified as shown in the following table:

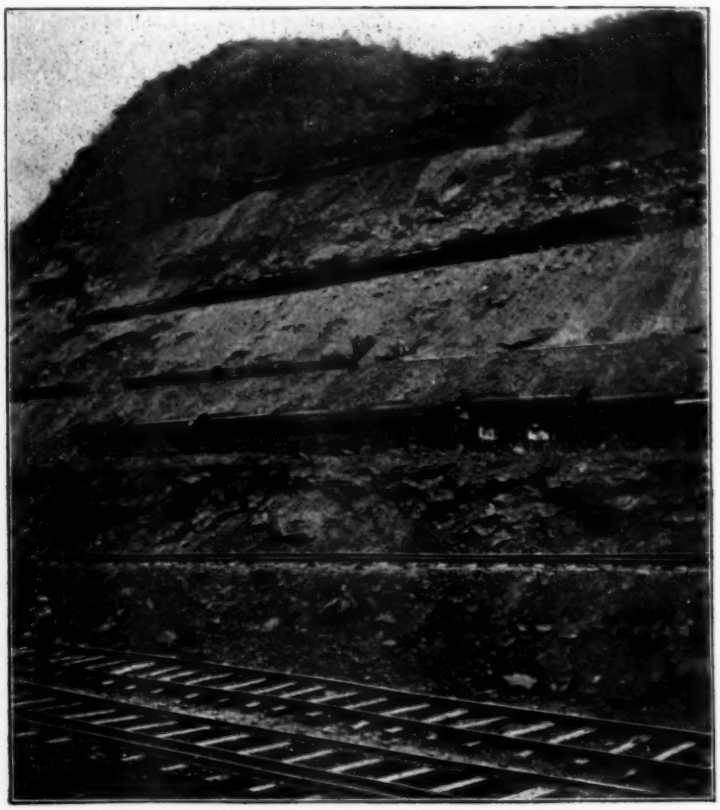
Dredging	27,659,540 cu. yds.
Dry earth	14,386,954 cu. yds.
Soft rock	39,893,235 cu. yds.
Hard rock	8,806,340 cu. yds.
Rock under water	4,891,667 cu. yds.
Embankment and back filling	1,802,753 cu. yds.
Total	97,440,489 cu. yds.
Concrete	3,762,175 cu. yds.
Granite	13,820 cu. yds.
Iron and steel	65,248,900 lbs.
Excavation in coffer dam	7,260 cu. yds.
Pneumatic work	108,410 cu. yds.

The lengths of the various sections of this route and the costs of completing the work upon them are fully set forth in the following table, taken from the commission's report, as were the two preceding:

Total Estimated Cost.	Miles.	Cost.
Colon entrance and harbor	2.39	$ 8,057,707
Harbor to Bohio locks, including levees	14.42	11,099,839
Bohio locks, including excavation	.35	11,567,275
Lake Bohio	13.61	2,952,154
Obispo gates		295,434
Culebra section	7.91	44,414,460
Pedro Miguel locks, including excavation and dam	.35	9,081,321
Pedro Miguel level	1.33	1,192,286
Miraflores locks, including excavation and spillway	.20	5,781,401
Pacific level	8.53	12,427,971
Bohio dam		6,369,640
Gigante spillway		1,209,419
Pena Blanca outlet		2,448,076
Chagres diversion		1,929,982
Gatun diversion		100,000
Panama Railroad diversion		1,267,500
Total	49.09	120,194,465
Engineering, police, sanitation and general contingencies, 20 per cent.		24,038,893
Aggregate		$144,233,358

The item in this table called Panama railroad diversion affords provision for the reconstruction of the railroad necessitated by the formation of Lake Bohio. That lake would submerge the present location of the railroad for fourteen or fifteen miles.

It will be observed that in the estimates of cost of the canal on both the Nicaragua and the Panama routes 20 per cent. is allowed for 'engineering, police, sanitation and general contingencies.' For the purposes of comparison the same percentage to cover these items was used



THE CULEBRA CUT.

on both routes. As a matter of fact the large amount of work which has already been performed on the Panama route removes many uncertainties as to the character of material and other features of difficulty which would be disclosed only after the beginning of the work in Nicaragua. It has therefore been contended with considerable basis of reason that a less percentage to cover these uncertainties should be employed in connection with the Panama estimates than in connection with those for the Nicaragua route. Indeed it might be maintained

that the exigencies which increase cost should be made proportional to the length of route and the untried features. On the other hand, both Panama and Colon are comparatively large centers of population, and, furthermore, there is a considerable population stretched along the line of the Panama railroad between those points. The climate and the unsanitary condition of practically every center of population in Central America and of the isthmus contribute to the continual presence of tropical fevers, and other diseases contingent upon the existing conditions of life. It is probable among other things that yellow fever is always present on the isthmus. Inasmuch as the Nicaragua route is practically without population the amount of disease existing along it is exceedingly small, there being practically no people to be sick. The initial expenditure for the sanitation of the cities at the extremities of the Panama route, as well as for the country between, would be far greater on the Panama route than on the Nicaragua. This fact compensates, to a substantial extent at least, for the physical uncertainties on the Nicaraguan line. Indeed a careful examination of all the conditions existing on both routes indicates the reasonableness of applying the same 20 per cent. to both total estimates of cost.

The preceding estimated cost of $144,233,358 for completing the Panama canal must be increased by the amount necessary to be paid for all the property and rights on the isthmus of the new Panama Canal Company. A large amount of excavation has been performed amounting to 77,000,000 cu. yds. of all classes of materials, and nearly all the right of way has been purchased. The new Panama Canal Company furnished the commission with a detailed inventory of its entire properties, which the latter classified as follows:

1. Lands not built on.
2. Buildings, 2,431 in number, divided among 47 subclassifications.
3. Furniture and stable outfit, with 17 subclassifications.
4. Floating plant and spare parts, with 24 subclassifications.
5. Rolling plant and spare parts, with 17 subclassifications.
6. Plant, stationary and semi-stationary, and spare parts, with 25 subclassifications.
7. Small material and spare parts, with 4 subclassifications.
8. Surgical and medical outfit.
9. Medical stores.
10. Office supplies, stationery.
11. Miscellaneous supplies, with 740 subclassifications.

The commission did not estimate any value for the vast amount of plant along the line of the canal as its condition in relation to actual use is uncertain, and the most of it would not be available for efficient and economical execution of the work by modern American methods. Again, a considerable amount of excavated material along some portions of the line has been deposited in spoil banks immediately adjacent to

the excavation from which it was taken, and would have to be rehandled in forming the increased size of prism contemplated in the commission's plan.

In view of all the conditions affecting it, the commission made the following estimate of the value of the property of the new Panama Canal Company, as it is now found on the Panama route:

Canal excavation	$21,020,386
Chagres diversion	178,186
Gatun diversion	1,396,456
Railroad diversion (four miles)	300,000
	$22,895,028
Contingencies, 20 per cent.	4,579,005
Aggregate	$27,474,033
Panama Railroad stock at par	6,850,000
Maps, drawings and records	2,000,000
Aggregate	$36,324,033

The commission added 10 per cent. to this total 'to cover omissions, making the total valuation of the property and rights as now existing $40,000,000.' In computing the value of the channel excavation in the above tabulation it was estimated that 'the total quantity of excavation which will be of value in the new plan is 39,586,332 cu. yds.'

In January, 1902, the new Panama Canal Company offered to sell and transfer to the United States Government all its property and rights on the isthmus of every description for the estimate of the commission, viz., $40,000,000. In order to make a proper comparison between the total costs of constructing the canal on the two routes it is necessary to add this $40,000,000 to the preceding aggregate of $144,233,358, making the total cost of the Panama canal $184,233,358. It will be remembered that the corresponding total cost of the Nicaragua canal would be $189,864,062.

It is obvious that the cost of operating and maintaining a ship canal across the American isthmus would be an annual charge of large amount. A large organized force would be requisite, and no small amount of material and work of various kinds and grades would be needed to maintain the works in suitable condition. The commission made very careful and thorough studies to ascertain as nearly as practicable what these comparative costs would be. In doing this it gave careful consideration to the annual expenditures made in maintaining the various ship canals of the world, including the Suez, Manchester, Kiehl and St. Mary's Falls Canals. The conclusion reached was that the estimated annual costs of maintenance and operation could reasonably be taken as follows:

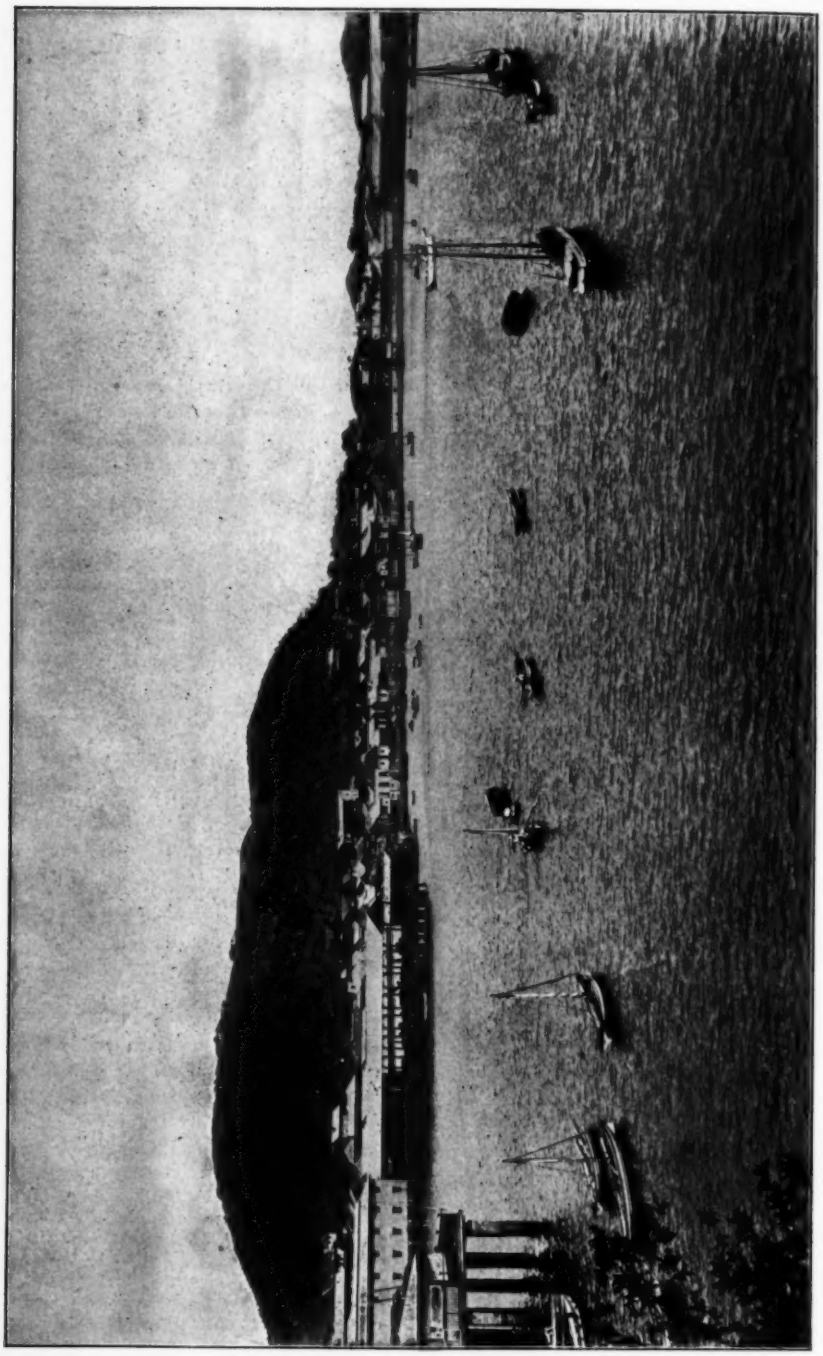
For the Nicaragua canal	$3,300,000
For the Panama canal	2,000,000
Difference in favor of Panama	$1,300,000

Much has been written regarding the comparative liability to damage of canal works along these two routes by volcanic or seismic agencies. As is well known, the entire Central American Isthmus is a volcanic region, and in the past a considerable number of destructive volcanic eruptions have taken place at a number of points. There is a line of live volcanoes extending southeasterly through Nicaragua and Costa Rica. Many earthquake shocks have occurred throughout Nicaragua, Costa Rica and the State of Panama, some of which have done more or less damage in large portions of those districts. At the same time many buildings, which have been injured, have not been

STREET IN PANAMA.

substantially built. In fact that has generally been the case. Both routes lie in districts that are doubtless subject to earthquake shocks, but there is little probability that the substantial structures of a canal along either line would be essentially injured by them. The conclusions of the commission as to this feature of the matter are concisely stated in three paragraphs at the top of page 170 of its report:

> It is possible and even probable that the more accurately fitting portions of the canal, such as the lock gates, may at times be distorted by earthquakes, and some inconvenience may result therefrom. That contingency may be classed with the accidental collision of ships with the gates, and is to be provided for in the same way, by duplicate gates.



BAY AND CITY OF PANAMA.

It is possible also that a fissure might open which would drain the canal, and if it remained open, might destroy it. This possibility should not be erected by the fancy into a threatening danger. If a timorous imagination is to be the guide, no great work can be undertaken anywhere. This risk may be classed with that of a great conflagration in a city like that of Chicago in 1871, or Boston in 1872.

It is the opinion of the commission that such danger as exists from earthquakes is essentially the same for both the Nicaragua and Panama routes, and that in neither case is it sufficient to prevent the construction of the canal.

The relative healthfulness of the two routes has already been touched upon. There is undoubtedly at the present time a vast amount of unhealthfulness on the Panama route, and practially none on the Nicaragua route, but this is accounted for when it is remembered, as has also been stated, that there is practically no population on the Nicaragua route and a comparatively large population along the Panama line. There is a widespread, popular impression that the Central American countries are necessarily intensely unhealthful. This is an error, in spite of the facts that the construction of the Panama Railroad was attended with an appalling amount of sickness and loss of life, and that records of many epidemics at other times and in other places exist in nearly all these countries. There are the best of good reasons to believe that with the enforcement of sanitary regulations, which are now well understood and completely available, the Central American countries would be as healthful as our southern states. A proper recognition of hygienic conditions of life suitable to a tropical climate would work wonders in Central America in reducing the death-rate. At the present time the domestic administration of most of the cities and towns of Nicaragua and Panama, as well as the generality of Central American cities, is characterized by the absence of practically everything which makes for public health, and by the presence of nearly every agency working for the diseases which flourish in tropical climates. When the United States Government reaches the point of actual construction of an isthmian canal the sanitary features of that work should be administered and enforced in every detail with rigor of the most exacting military discipline. Under such conditions, epidemics could either be avoided or reduced to manageable dimensions, but not otherwise. The commission concluded that, 'existing conditions indicate hygienic advantages for the Nicaragua route although it is probable that no less effective sanitary measures must be taken during construction in the one case than in the other.'

The time required for passing through a trans-isthmian canal is affected by the length, by the number of locks, by the number of curves, and by the sharpness of curvature. The speed of a ship and consequently the time of passage is also affected by the depth of water under its keel. It is well known that the same power applied to a ship in deep

water of unlimited width will produce a much higher rate of movement than the same power applied to the same ship in a restricted waterway, especially when the draft of the ship is but little less than the depth of the water. These considerations have important bearings both upon the dimensions of a ship canal and upon the time required to pass through it. They were most carefully considered by the commission, as were also such other matters as the delay incurred in passing through the locks on each line, the latter including the delay of slowing or approaching the lock and of increasing speed after passing it, the time of opening and closing the gates, and the time of emptying and filling the locks. It is also evident that ships of various sizes will require different times for their passage. After giving due weight to all these considerations it was found that what may be called an average ship would require twelve hours for passing through the Panama canal, and thirty-three hours for passing through the Nicaragua canal. Approximately speaking, therefore, it may be stated that an average passage through the former water-way will require but one third the time needed for the latter.

The time in which an isthmian canal may be completed and ready for traffic is an element of the problem of much importance. There are two features of the work to be done at Panama, each of which is of sufficient magnitude to affect to a controlling extent the time required for the construction of the canal, viz., the Bohio dam and the Culebra cut. Both of these portions of the work may, however, be prosecuted concurrently, and with entire independence of each other. There are no such features on the Nicaragua route, although the cut through the divide west of the lake is probably the largest single work on that route. In considering this feature of the matter it is well to observe that the total amount of excavation and embankment of all grades on the Nicaragua route is practially 228,000,000 cu. yds., while that remaining to be done on the Panama route is but little more than 97,000,000 cu. yds. or 43 per cent. of the former.

The commission has estimated ten years for the completion of the canal on the Panama route and eight years for the Nicaragua route, including in both cases the time required for preparation and that consumed by unforeseen delays. The writer believes that the actual circumstances attending work on the two routes would justify an exchange of these time relations. There is great concentration of work in the Culebra-Emperador cut, on the Panama route, covering about forty-five per cent. of the total excavation of all grades (43,000,000 cu. yds.), which is distributed over a distance of about seven miles with the location of greatest intensity at Culebra. This demands efficient organization and special plant so administered as to reduce the working force to an absolute minimum by the employment of machinery to the

greatest possible extent. A judicious, effective organization and plant would transform the execution of this work into what may be called a manufactory of excavation with all the intensity of direction and efficiency of well-designed and administered machinery which characterizes the concentration of labor and mechanical appliances in great manufacturing establishments. Such a successful installation would involve scarcely more advance in contract operations than was exhibited, in its day, in the execution of the work on the Chicago Drainage Canal. By such means only can the peculiar difficulties attendant upon the execution of great works in the tropics be reduced to controllable dimen-

VIEW ON THE SAN JUAN RIVER IN NICARAGUA.

sions. The same general observations may be applied to the construction of the Bohio dam, even should a no more favorable site be found.

The greatest concentration of excavation on the Nicaragua route is between the lake and the Pacific, but it constitutes only ten per cent. of the total excavation of all grades, and it can be completed in far less time than the great cut on the Panama route. If this were the only great feature of work besides the dam, the time for completion of work on this route would be materially less than that required for the Panama crossing. As a matter of fact there are a succession of features of equivalent magnitude, or very nearly so, from Greytown nearly to Brito, extending over a distance of at least 175 miles, requiring the construction of a substantial service railroad over a considerable portion of the distance prior to the beginning of work. This attenuation of

work requires the larger features to be executed in succession to a considerable extent, or much duplication of plant and the employment of a great force of laborers, practically all of whom must be foreigners, housed, organized and maintained in a practically uninhabited tropical country where many serious difficulties reach a maximum. It is not within the experience of civil engineers to execute by any practicable means that kind of a program on schedule time. The weight of this observation is much increased when it is remembered that the total volume of work may be taken as nearly twice as great in Nicaragua as at Panama, and that large portions between Lake Nicaragua and the Caribbean Sea must be executed in a region of continual and enormous rainfall. It would seem more reasonable to the writer to estimate eight years for the completion of the Panama canal and ten years for the completion of the Nicaragua canal.

The prospective industrial and commercial value of the canal also occupied the attention of the commission in a broad and careful study of the elements which enter that part of the problem. It is difficult if not impossible to predict just what the effect of a trans-isthmian canal would be either upon the ocean commerce of the United States, or of other parts of the world, but it seems reasonable to suppose from the result of the commission's examinations that had the canal been in existence in 1899 at least 5,000,000 tons of the actual traffic of that year would have been accommodated by it. The opening of such a waterway, like the opening of all other traffic routes, induces the creation of new traffic to an extent that cannot be estimated, but it would appear to be reasonable to suppose that within ten years from the date of its opening the vessel tonnage using it would not be less than 10,000,000 tons.

The Nicaragua route would favor in distance the traffic between our Atlantic, including Gulf, and Pacific ports. The distances between our Atlantic ports and San Francisco would be about 378 nautical miles less than by Panama. Between New Orleans and San Francisco, this difference in favor of the route by Greytown and Brito would be 580 nautical miles. It must be remembered, however, that the greater time by at least twenty-four hours, required for passage through the Nicaragua canal, practically obliterates this advantage, and in some cases would throw the advantage in favor of the Panama waterway. This last observation would hold with particular force if for any reason a vessel should not continue her passage, or should continue it at a reduced speed during hours of darkness, which could not be escaped on the Nicaragua canal, but might be avoided at Panama. For all traffic between the Atlantic, including gulf ports, and the west coast of South America, the Panama crossing would be the most advantageous. As a matter of fact, while there may be some small advantage in miles

by one route or the other for the traffic between some particular points, on the whole neither route would have any very great advantage over the other in point of distance or time; either would serve efficiently the purposes of all ocean traffic in which the ports of the United States are directly interested.

The effect of this ship waterway upon the well-being of the United States is not altogether of a commercial character. As indicated by the commission, this additional bond between the two portions of the country will have a beneficial effect upon the unity of the political interests, as well as upon the commercial welfare of the country. Indeed, it is the judgment of many well-informed people that the commercial advantages resulting from a closer touch between the Atlantic and Pacific coasts of the country are of less consequence than the unifying of political interests.

THE BREAKWATER OF THE MARITIME CANAL COMPANY AT THE FORMER ENTRANCE (NOW FILLED) TO GREYTOWN HARBOR ON THE COAST OF NICARAGUA.

Concisely stating the situation, its main feature may be expressed somewhat as follows:

Both routes are entirely 'practicable and feasible.'

Neither route has any material commercial advantage over the other as to time, although the distance between our Atlantic (including Gulf) and Pacific ports is less by the Nicaragua route.

The Panama route is about one fourth the length of that in Nicaragua; it has less locks, less elevation of summit-level, and far less curvature, all contributing to correspondingly decreased risks peculiar to the passage through a canal. The estimated annual cost of operation and maintenance of the Panama route is but six tenths that for the Nicaragua route.

The harbor features may be made adequate for all the needs of a canal by either route, with such little preponderance of advantage as may exist in favor of the Panama crossing.

The commission estimated ten years for the completion of the Panama canal and eight years for the Nicaragua waterway, but the writer believes that these relations should be exchanged.

The water-supply is practically unlimited on both routes, but the controlling or regulating works, being automatic, are much simpler and more easily operated and maintained on the Panama route.

The Nicaragua route is practically uninhabited and consequently practically no sickness exists there. On the Panama route, on the contrary, there is a considerable population extending along the entire line, among which yellow fever and other tropical diseases are probably always found. Initial sanitary works of much larger magnitude would be required on the Panama route than on the Nicaragua, although probably as rigorous sanitary measures would be required during the construction of the canal on one route as on the other.

The railroad on the Panama route and other facilities offered by a considerable existing population render the beginning of work and the housing and organization of the requisite labor forces less difficult and more prompt than on the Nicaragua route.

The greater amount of work on the Nicaragua route, and its distribution over a far greater length of line, involve the employment of a correspondingly greater force of laborers with attendant difficulties for an equally prompt completion of the work.

The recent volcanic eruptions on the Island of Martinique indicate a possible danger to the Nicaragua canal, should it be built, from the living volcano of Ometepe in Lake Nicaragua about ten miles from the land line. That there is some danger is beyond question, but it is very remote. There is no evidence to show that a canal or canal structure ten miles distant from Mount Pelee would have been injured by its recent eruptions, although navigation might have been interrupted for a short time. It is an open question, therefore, whether Ometepe in most violent eruption, even, would injure the Nicaragua Canal, although danger would exist.

On the other hand, as there is no volcano within about 175 miles of the Panama route, that route would be free from all danger of volcanic eruption.

Concessions and treaties require to be secured and negotiated for the construction of the canal on either route, and under the conditions created by the $40,000,000 offer for the new Panama Canal Company this feature of both routes appears to possess about the same characteristics, although the Nicaragua route is perhaps, freer from the complicating shadows of prior rights and concessions.

SOCIAL BACTERIA AND ECONOMIC MICROBES, WHOLESOME AND NOXIOUS. A STUDY IN SMALLS.

By EDWARD ATKINSON, LL.D., PH.D.

The profit of each generation, or in the present era the profit of each decade, consists in the saving of what was wasted in the last one.

I HAVE long sought a method by which the value of the annual product of this country at the prices fixed at final distribution, commonly called retail prices, might be ascertained with approximate accuracy.

In the study of the data of 1880 I was led to the conclusion that the average per capita expenditure (and therefore the annual product in its final stage) of the people of this country for the necessaries, comforts and luxuries of life could not be less than what $200 per head could buy at the prices of the census year. The proportion of the population occupied for gain varied but a fraction from one in three, leading to the conclusion that the average product of each person occupied for gain could not be less than $600 worth a year. Assuming this estimate to be approximately correct, this sum must have been the measure in money within which the cost of living, the taxes, additions to capital and all personal expenditures must have been covered. But on multiplying the population of the census year 1880 by $200 worth per head, I was led to a very much larger estimate of the value of the annual product than the estimates of any other student of social facts.

I revised this computation on the basis of the census of 1890, reaching a conclusion that, while prices had been lessened, the value of the annual product at the lessened prices had reached not less than $225 worth per head or $675 per person occupied for gain.

Upon revising the figures of 1900 as far as given—these figures being more adequate than any before compiled—I have again reached the conclusion that the per capita product of the year reported in the census of 1900 was not less than what $225 per capita would come to, each dollar of that $225 standing on the average for a considerably larger quantity of products than ever before. At the present time prices have been enhanced, in consequence mainly of a short product of Indian corn, of potatoes and other root crops, and of some other products; but under the present aspect of ample crops and normal production a return to normal conditions may be anticipated within a few months or by the time when the population of this country will

number 80,000,000, say in 1903–4. For convenience in this preliminary study I therefore use 80,000,000 as the factor of population. I have computed the per capita expenditures on many lines from the data of 1900 and 1901, then by multiplying these normal figures of the two normal years before the effect of the short crop of 1901. In this way I compute the per capita and the gross value of each subject treated as it will be on a population numbering 80,000,000. This is only a preliminary study, subject to correction and completion after the final data of the census of 1900 become available; also subject to verification by other methods than the official census, such as I have made use of in this partial analysis.

Within the limited time and space allowed I can not cite authorities. Suffice it that I have, as far as possible, verified figures by reference to the special experts of the census and to various students of specific arts and subjects; notably in iron and steel, liquors, tobacco, cottons, woolens, dairy products, etc.; to all of whom I shall give credit when this preliminary study has been carried to completion.

Item No. 1, *Liquors, Divided into Spirits, Wines and Fermented Liquors.*—The average consumption of liquors has been computed in the Bureau of Statistics of the Treasury Department for many years with outside aid from a special trade expert. It has also been computed year by year by the editor of the *American Grocer*. The two estimates vary. The estimate of the *American Grocer* of the per capita expenditure comes to $14.20. The official estimate for the same year comes to $17.90. The latter may be more reasonably accepted than the former conservative estimate. This annual expenditure appears to be very large, but it proves in fact that the people of the United States are temperate as compared with European nations. It is evident that, since quantities are measured by taxation and values can be readily measured at the points of distribution, this computation is subject to a very small margin of error. The editor of the *American Grocer* computes spirits at forty-eight drinks to a gallon, which is the measure of standard liquor per drink in the best clubs. At his estimate of the total quantity, 1.33 gallons per head and amount expended, the average charge per glass of liquor is less than ten cents. Now in view of the custom of watering liquor, making at least sixty drinks to a gallon, and the probably average higher charge than ten cents a drink, his expenditure for spirits is probably too low.*

* Quantity of spirits estimated and taxed in the year 1901, 87,086,839 gallons, at 48 drinks per gallon computed at $4.50 retail, $391,890,775, if all were consumed as a beverage. In that year there were 26,000,000 males of seventeen years of age and over. The quantity named would give less than half a drink a day to this number. Drinks are at the rate of one or more per day. It follows that less than half the males of seventeen or over ever drink spirits, and by as much as some drink more must others go without.

Again, the consumption of beer at sixteen gallons per head is computed at retail prices in half-pint service. The half-pint drink is seldom of full measure, and the sum of this computation would yield only a fraction over three cents per glass. I think no beer is sold at retail at less than five cents per glass.*

How the government estimate is computed I know not, but from these figures one may accept the government rather than the *Grocer's* estimate. I think it is safe to adopt an average of not less than $17 per head for spirits, wines and beer, which, assessed upon 80,000,000 people, would come to $1,360,000,000.

It may be remarked that the consumption of spirits has been very uniform at 1.33 gallons per head for a long period, slightly diminishing rather than increasing for several years. It is at about the same average as that of the United Kingdom of Great Britain and Ireland. On the other hand, our consumption of beer has rapidly increased, reaching a fraction over sixteen gallons per head of light beer, against an average in England of thirty-five gallons per head of strong beer. The price of beer is lower in Great Britain, but the average expenditure for drink is established at twenty dollars per head. The consumption of liquors in France and Germany is also much greater than in the United States.

Item No. 2, *Tobacco, Cigars, Cigarettes, Chewing Tobacco and Snuff.*—The consumption of tobacco has also been computed year by year by the editor of the *Tobacco World,* by whom a very close analysis has been made, which time will not permit me to quote in full. This estimate clearly proves that the average expenditure comes to $6.15 per head, say $6, or on a population of eighty million, $480,000,000. †

* The quantity of beer consumed in 1901 was 1,254,653,009 gallons at 16.20 gallons per head, which the editor of the *American Grocer* computes at fifty cents per gallon at retail, $630,922,886. One gallon yields sixteen half pints. At fifty cents a gallon that comes to a fraction over three cents for a full half pint, which is too low an estimate. This quantity at 16.20 gallons per head would yield only half a pint a day to 29,160,000 people out of over 76,000,000, and as those who drink beer habitually far exceed half a pint a day, it follows that probably not half of the adults drink beer.

† This computation of six dollars per head of population would give each person less than two cents' worth of tobacco a day. But a considerable part of the population goes without tobacco in their early years. It would seem but a small allowance if we estimated that the users of tobacco averaged four cents' worth per day, and at that rate the estimate of the *Tobacco World* would supply only a little over a half of the population. Do half the population use four cents' worth of tobacco per day? If they do, by so much as some use more others must go without. I shall leave it to each smoker to compute the price of his own consumption of tobacco or cigars by his own average. I am afraid I deprive a great many other men of this solace by my own excess—over four cents a day.

I think it is clearly proved that the annual expenditures of the people of the United States for liquors and tobacco must come to at least $23 per head of the whole population, amounting on eighty million people to $1,840,000,000 in one year.

But there is an unknown addition which can not be readily computed but which should be added to this expenditure. The editor of the *American Grocer* deducts from the quantity of spirits consumed as a beverage from which the government revenues are derived 16,000,000 gallons, said to be used in the arts. There is reason to believe that more than half the quantity of spirits said to be used in the arts is consumed in making beverages, temperance drinks and quack or proprietary medicines, for which a very high price is paid by ignorant or uninformed persons, many of whom are totally unaware of the fact that they are drinking intoxicating liquor. I will not attempt to add an estimate in money for this waste, resting on the average of $23 per head on 80,000,000 population, $1,840,000,000, which, it will be observed, is ten per cent. of my large estimate of the total expenditures of the people of this country for food, clothing and shelter and all other products necessary to life.*

Omitting the short period of war revenues, 1898 to 1902, now abated, the revenue derived by the Government of the United States from liquors and tobacco, domestic and foreign, for twenty years before the beginning of the Spanish War averaged $2.50 per head, to which rate we may return after July 1, 1902, which rate on 80,000,000 people will yield $200,000,000 a year. During the same twenty years prior to the Spanish War this revenue from liquors and tobacco, at $2.50 per head, covered all the normal expenditures of the government of the United States, except interest and pensions, year by year, at $2.50 per head, varying but slightly, namely, the cost of the civil, judicial and legislative departments, the support of the army and of the navy (including naval construction during those twenty years), public buildings, deficiency in postal service and all other normal expenditures.

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* PER CENT. ALCOHOL BY VOLUME IN VARIOUS COMPOUNDS.

Ayer's Sarsaparilla,	26.2	per cent.
Hood's "	18.8	" "
Golden's Liquid Beef Tonic, 'recommended for treatment of the alcohol habit,'	26.5	" "
Liebig Company's Cocoa Beef Tonic,	23.2	" "
Praker's Tonic, 'purely vegetable, recommended for inebriates,'	41.6	" "
Boker's Stomach Bitters,	42.6	" "
Warner's Safe Tonic Bitters,	35.7	" "

For an analysis of a very large number of these nostrums, not only in respect to alcohol, but for the proportion of iodide of potassium and other poisonous drugs and chemicals, see 'Report of Massachusetts Board of Health,' Pub. Doc. No. 34, pp. 614 to 620 inclusive; published in a separate pamphlet.

It will be remarked that when the government again derives a revenue of $2.50 per head or $200,000,000 per year from liquors and tobacco after July 1, 1902, that revenue will constitute a little less than eleven per cent. of the total expenditure for liquors and tobacco computed at $1,840,000,000.

Again, assuming that these expenditures for liquors and tobacco are equal to ten per cent. of the entire cost of living of the whole population, then the government tax upon liquors and tobacco comes to a little more than one per cent., which is assessed upon the total product of the entire country estimated at $225 per head at retail prices. Yet this tax is a purely voluntary contribution to the support of the government. Those who consume neither liquor nor tobacco pay none of this tax; those who do consume these articles pay the tax in the exact proportion of their consumption.

Item No. 3, *Wheat or White Bread.*—A few years since a well-established estimate of the consumption of wheat flour per head of population was one barrel, say 200 pounds, per year. Since then the increased product of wheat, the lessened price and the greater ability of the masses of the people to consume white bread brings that estimate up from 200 pounds to at least 230 pounds of flour. Assuming that the retail price of flour on the average of all parts of the country is two cents a pound, or four dollars a barrel, or $4.60 per head of population on a consumption of 230 pounds each, the cost of flour to 80,000,000 persons would be $368,000,000. Two hundred and thirty pounds of flour will make 325 pounds of bread, yielding a little short of a pound of bread a day per head of population.

I can make and bake six loaves of bread, weighing twelve pounds, in an Aladdin oven with an expenditure of less than two cents for fuel oil burned in a common lamp with some trifling addition for yeast and salt. In other words, a little over eight pounds of flour, costing between seventeen and eighteen cents for the best kinds, can be converted into twelve pounds of bread at a cost of much less than two cents a pound of bread. What then is the cost of bread to the mass of the consumers? What proportion make their own bread? What proportion buy it? This is a problem of difficult solution.

I find that the price of bread in Boston, delivered by grocers and bakers, ranges from a little less than five cents a pound for very poor bread up to ten cents a pound for very good bread. Bread delivered in New York of an average better quality costs less to the consumer. What it is in other cities or in the country I am unable to state. But in view of the large amount of wheat flour which is converted into cake, into fancy biscuits and into pastry, it may not be out of the way to compute 325 pounds of bread per capita at four cents a pound or

$13 per head expended for wheat flour when converted into bread, cake, biscuit, pastry and cereals equals $1,040,000,000.

What should be added for bread made of other grain? In the South corn meal is probably used in larger quantity per capita than wheat flour. Large quantities of corn meal, rye meal and oatmeal also serve as bread or as cereal food. There would probably be but a small margin of error if we computed the cost of other grains than wheat in the form of bread or cereal food at $6 per head, making the total grain bill $19 per head, or on 80,000,000 people $1,520,000,000; being considerably less than the expenditure for liquors and tobacco.*

This brings out the most important question in practical economics. If I can buy the best wheat flour and with twenty minutes a day of light exercise make one pound of bread each for twelve persons—bread-making being one of the simplest arts and one most easily learned; and if this bread costs less than two cents a pound, why should the bread of the masses of the people in the cities cost them more than four cents; or, in other words, what are the relative charges for distribution? The barrel of flour of which my bread is made has been brought to me a thousand miles at a charge of 50 cents or less, of which 30 cents may represent the cost of the service and 20 cents the possible net revenue of the railway to be applied to the payment of interest on bonds or dividends on the stock. That barrel of flour, making 280 pounds of bread, divided into 50 cents, charge for railway transportation, makes the cost of that part of the railway distribution of the loaf less than two tenths of a cent per pound of bread. On the other hand, the cost of distributing the loaves of bread in the city after they have left the mouth of the baker's oven is more than two cents per pound. The misdirected energy of the community has been devoted to denunciation of the railway service and to misdirected efforts to cheapen the cost of food by compelling railway corporations to lessen their rates whether they are profitable or not, while little or no attention has been given to improving the methods of distribution of bread at retail or to getting rid of the exorbitant charge for distributing loaves of bread at the rate of two cents a pound or more as compared to two tenths of a cent a pound or less over the railway. This observation will apply to nearly every article which enters into the cost of subsistence, especially the distribution of fresh vegetables. How to reduce the cost of distributing the necessaries of life in small parcels and how to save the waste of good

* An observation in smalls discloses the fact that the one machine shop now making 45 per cent. of the twine-binding grain harvesters of this country now turns out one complete harvester every eighteen seconds during eight working hours of each day for 300 days in the year, and being unable to meet the increasing domestic and foreign demand the company is now extending its works so as to turn out one every ten seconds.

material after it has been distributed are the real problems for practical economists to deal with.

Item No. 4, *Sugar.*—The import and production of sugar are well established in quantity and value; the consumption per capita is known; it is one of the articles on which the cost of refining has been reduced to the smallest fraction, and both the wholesale and retail profits to the lowest point. The latest consumption has been fixed at 68 pounds per head, without counting molasses. If we add the molasses at a very small fraction, we may count the average consumption at 70 pounds per head at an average price of five cents a pound or $3.50 per head for refined sugar. But a quantity which cannot be measured is converted over into jams, jellies, preserves and condensed milk. In the latter industry one single establishment is reputed to consume more than the entire product of all the beet-root sugar factories in this country, estimated at about 150,000 tons. If sugar were free of duty an immense impulse would be given to agriculture and to fruit growing. A very small number of persons can ever be employed in raising beets for sugar, because the weeding of the beets must be done by hand and there are very few sections of the country where the people are so poor as to find suitable employment in this occupation, but with free sugar an immense impulse will be given to the making of condensed milk for home use and export, and to the saving of fruit now wasted, for conversion into jams, jellies and preserves. We should take the commerce of the world on these lines, and by free sugar provide excellent employment for ten where one can ever be occupied in raising beets.

Another large quantity of sugar is converted into candy. None can measure this factor. The highest rentals at the corners of the most frequented streets in cities are paid for occupation in the distribution of candy. I happen to know of four corners now occupied in Boston on which the rental is more than $25,000 a year, these shops being devoted exclusively to retail traffic in candy of all sorts with prices of from ten to forty cents a pound. It follows that at least fifty cents per head should be added to the retail price of the refined sugar, making the total expenditure for sugar four dollars per head, or on a population numbering 80,000,000, $320,000,000 a year.

Item No. 5, *Meats and Vegetables.*—It will be impossible to deal with the average expenditure for meat at the present time. Poultry and eggs at farm values come to $3.69 per head. The product of slaughtering establishments large enough to be included under the head of 'Manufacturers' in the census comes to $10.31 per head at the works. Butter, cheese and condensed milk at such works as are big enough to be included in the census come to $1.72 per head. But more animals are slaughtered outside the large establishments than in them. The figures of poultry and eggs, of butter, cheese and con-

densed milk are probably not half what they are at the farms if farm products are added to census figures. When the agricultural reports are finally published and compared with the census figures it will become possible to reduce these factors to terms very closely approximating the average per capita expenditures for consumption. The only item of necessary expenditure which exceeds liquors and tobacco is the expenditure upon animal food. The expenditure for beer is less than five cents a day per capita; how much is the cost of milk?

Item No. 6, *Pig Iron.*—The people of the United States are not only the largest producers but also the largest consumers of pig iron in the world; yet at 450 pounds per head, which is nearly double the domestic consumption of England, Belgium, France and Germany, who are our chief competitors, the average per capita product of pig iron at the works comes to only $4.50 per head. Prices are rising and consumption is increasing; by the time we have 80,000,000 people the average consumption will probably be 500 pounds per head if the works can supply it, which may then be computed at about five dollars per head for the average of forge iron, Bessemer metal, and of iron ore converted into open hearth steel, in their crude forms at the works; making on 80,000,000 a consumption of $400,000,000 worth at the place of production. In order to carry this crude iron and steel into their finished forms through various transformations, it is probable that at the points of final consumption the products of iron and steel may be rated at about $12.50 per head, or on 80,000,000 population $1,000,000,000, a little more than half the price paid for liquors and tobacco. So much for some of the chief factors in production and consumption.

In this way I have given a preliminary study of the value of the annual product at its point of ultimate consumption or export. By making the study in smalls I have attempted to call your attention to the relative importance of several elements of subsistence. It will be several months before this study can be completed; suffice it that I have gone far enough to prove conclusively to my own mind that even on the return to normal prices, which may ensue if we have good crops this year before the population of the country reaches 80,000,000, the average of $225 per head or more will be proved, on which basis the annual product computed at that date and in that manner will be measured by the sum of $18,000,000,000. It may then be possible to estimate the proportion which this product will bear to the capital of the nation, which will require a separation of the site value of land from the estimate of national wealth by which the public is deluded. What really constitutes national wealth is the use made of land and the improvements placed upon it by human energy.

I may now give you some curious examples of how the income derived from the production, purchase and sale of these commodities

is distributed by way of railway charges, duties, national expenditures, support of schools, fire losses and losses by commercial failures.

Item No. 7, *Tea, Coffee and Cocoa.*—The editor of the *American Grocer* computes the annual expenditure for tea, coffee and cocoa by a method that leaves very little margin for error and which gives $2.34 per head; which assessed on 80,000,000 comes to $187,200,000. This sum added to the amount computed for liquor and tobacco gives a fraction over $25 per head for beverages and tobacco, or over $2,000,000,000 a year.

Item No. 8, *Textile Fabrics.*—The census data on cotton, woolen and silk fabrics, deducting exports and adding imports, gives approximately $15 per head for clothing materials and carpets at the works. The extension of these values at mills in clothing and other uses will give approximately $30 per head as the expenditure of consumers on this class; which assessed on 80,000,000 comes to $2,400,000,000. After consultation with clothing manufacturers, I put cotton clothing at $8 per head, woolen, $12, silks, linens, laces, embroideries, etc., etc., at $10, subject to further study.

Item No. 9, *Boots and Shoes.*—The value at the factories is $3.42 per head, approximately $5 to consumers; which assessed on 80,000,000 comes to $400,000,000.

Item No. 10, *Wool.*—The average value of the annual wool clip of the United States at the farms and ranches comes to 66 cents per head. The maximum value of the largest product of beet root sugar is 10 cents, making together 76 cents; which sum assessed on 80,000,000 people amounts to $62,800,000, or a sum not exceeding 1½ per cent. of the total product of agriculture in a normal year. Yet the farmers have been led to believe that their interests demand almost prohibitive duties on these two petty products, leading them to support a policy which costs them in the price of their clothing and sugar twice or thrice the total value of these two products, which duties obstruct the export of their surplus of the principal crops and the development of domestic industry in the most obnoxious way.

We may now deal with a few other problems of distribution which may be of interest.

The freight charges on all the railways of the United States in the year 1900 amounted to a little over $1,071,000,000, which was at the rate of three quarters of a cent per ton per mile, and at the rate of $13.79 per capita, which may be compared with $23 per head for liquors and tobacco.

For this sum of $13.79, 14 tons of food, fuel, fibers and fabrics were hauled 142 miles for every man, woman and child of the population. The average capital invested per capita amounted to $151, on which

the railway corporations succeeded in earning $5.13, or 3½ per cent. on the average per year.

The highways of the country are free, and those who feel themselves oppressed by these great combinations of capital are also free to cart their own 14 tons 142 miles in their own way if they want to. For myself I prefer to hire Morgan, Gould, Harriman and the Vanderbilts to do my carting.

The Support of Schools.

The annual appropriation for the support of common schools ranges from less than one dollar per head in many States to five dollars per head in Massachusetts. The average is three dollars per head, which sum assessed on 80,000,000 comes to $240,000,000. Schools are the antidote for liquor—when the money spent on schools exceeds the money spent on whiskey we may boast of our progress.

National Expenditures.

The amount expended in the year ending June 30, 1901, for civil, judicial, postal service, public buildings, Army and Navy on a peace basis, may be computed at the normal rate of.....	$2.50	per capita.
Pensions, ...	1.79	" "
Interest, ...	.42	" "
Normal expenditure free from warfare, ...	$4.71	
Cost of militarism and of the attempt to subjugate the people of the Philippine Islands, ...	1.86	
Total, ...	$6.57	
The cost of militarism, mainly expended in the effort to subjugate the Philippine Islands amounted to.....	$144,183,239	

Our exports to the Philippine Islands in the same year amounted to less than four cents per head of our population. We have wasted nearly two dollars a head for two or three years in the effort to control an export at four cents a head.

I submit this preliminary and partial analysis of consumption for criticism and suggestion. It will require some weeks of close study of the census and other data for its completion. I may hope to finish this work soon after July 1, and expect to prove that my estimate of our annual product at $225 per head will be more than sustained.

In conclusion I may call attention to what I believe to be the facts. The normal rate per capita of our national expenditures at $5 per head, tending in time of peace to diminish, bears a ratio of not exceeding 2½ per cent. to my estimate of the national product. Even at the present rate of about $6.50 per head, imposed upon us by our temporary military aberration, it does not reach three per cent.

Our principal competitors in the great commerce of the world—Great Britain, France, Germany, Belgium and the Netherlands—are subject to an average rate of $14 to $15 per capita, mostly imposed to meet the interest on war debts and the cost of militarism. This burden, tending to increase, stands for a rate of from eight to fifteen per cent. on their lesser national product.

On this difference only we save from $700,000,000 to $800,000,000 a year, or, in other words, gain that amount which our principal competitors now waste in destructive preparation for war.

People of some prominence in political and clerical life often expose their shallow capacity or their ignorance, by sneering at 'commercialism,' and by trying to discredit those who oppose the brutality of war by speaking of commerce as a mean and selfish pursuit.

Commerce lives and moves and has its being in mutual service rendered by men and nations for mutual benefit. It demands peace, order and industry.

War exists because of the survival of the brute element in man, which has not yet been overcome by education.

As surely as Christianity will displace paganism, as surely as civilization will displace barbarism, as surely as intelligence and education will displace ignorance, so surely will the beneficent force of commerce suppress the barbarity and brutality of war.

MARRIAGE AMONG EMINENT MEN.

By Professor EDWARD L. THORNDIKE,
TEACHERS COLLEGE, COLUMBIA UNIVERSITY.

THE failure of the human race to reproduce at the top has been the cause of frequent complaints by students of society. The necessity of improving the human species by perpetuating desirable strains and restricting the increase of defectives, delinquents and dependents has impressed every thoughtful observer of human affairs and led him to wonder to what extent various classes of men share in producing the next generation. The reply has commonly been the cheerless dogma that the top strata of society are constantly dying out, that gifted men and women marry much less and later and have fewer children than the thoughtless multitude.

I have tested two of these claims in the case of the eminent men of our own country. The results have more than a curious interest. The well-known 'Who's Who in America' contains the names of about 10,000 men. Some of these are grotesquely out of place and many eminent men are missing from the list. But if we select 1,000 or more, we have a body of men representative surely of the top hundredth if not of the top five hundredth of men of their age. Their attitude toward marriage will give an idea of the attitude of men who have shown superiority over at least 99 per cent. of their fellow men.

The facts cannot be stated with absolute precision since a large percentage of them do not make any report at all concerning their conjugal condition. In an investigation of a number of these cases it was found that three fourths were married. Applying this fact to the whole group we obtain the following figures:

Of 286 eminent men, between 60 and 70 years old, 88 per cent. are married.
Of 347 eminent men, between 50 and 60 years old, 88 per cent. are married.
Of 342 eminent men, between 40 and 50 years old, 88 per cent. are married.
Of 243 eminent men, between 30 and 40 years old, 85 per cent. are married.

Comparing these percentages with similar ones for the whole male population, we have

Eminent men.	Whole population.
60–70 yrs. 88	93
50–60 yrs. 88	92
40–50 yrs. 88	89
30–40 yrs. 85	79 (about 85 for ages exactly corresponding to those of eminent men)

There is thus little or no avoidance of marriage peculiar to gifted men. The contrary belief seems one of the numerous scientific superstitions.

If we examine their age at marriage, we may justify the claim that gifted men marry not only almost as commonly, but also as early as the rank and file. Of those who have reached the age of forty-four and married before forty-five, 22.2 per cent. married before the age of 25, 43.3 per cent. between 25 and 30, 18.7 per cent. between 30 and 35 and 15.8 per cent. between 35 and 45. The corresponding figures for the general male population of the United States are 22.7, 41.0, 23.1 and 13.1.

Obviously the gifted men marry at almost the same ages as the multitude. Even the slight differences observable might vanish if the statistics were freed from the tendency to report the date of a second rather than a first marriage.

The facts concerning the marriages of gifted men in America seem to disprove another common dogma—that the age at marriage has been rapidly increasing in the case of professional men because of the increasing amount of preparation required for success in professional life under present conditions. If we take all the gifted men born before 1865, who have married before 35, and compute the average age at marriage of those born before 1820, from '20 to '30, from '30 to '40, etc., we find that the age of marriage for gifted men has probably advanced less than six months in a half century. This is a liberal estimate and is surely not alarming. I find no means of ascertaining the change in the marriage age of the general male population during the same period, but there is no evidence that professional men differ from authors, artists or men in business.

These facts witness to the fundamental conservatism of human nature. The casual observer is impressed by the appearance of changes —of revolutions and reformations in human ways; he fancies that some force in the environment is making or marring our customs. But the inborn make-up of men is always a factor and one that remains unaltered through many half centuries.

UNIVERSITY-BUILDING.

By President DAVID STARR JORDAN,
LELAND STANFORD JUNIOR UNIVERSITY.

WITH the end of our republic's first century we had the first clear vision of the greatest of republican institutions, the American university. It was even then only a vision. It is not yet realized, but we know something of what it is to be. Out of the struggles and the prayers, the hopes and the efforts of good men and good women we see it taking form. A university, as fair as those which England has known for a thousand years, as sound and as strong as the deep-rooted schools of Germany, with something of both, yet different from either, is the coming university of America. There will be many of these institutions, for our land is very wide, and they will differ from each other somewhat in kind and as one star differeth from another in glory, still of the same general pattern all must be. They will be schools for training American boys and girls to be American men and women. They will express the loftiest ideals of higher education within our great democracy.

The American college, as it existed thirty years ago and more, and as it still exists in some quarters, is distinctly a school for personal culture. Its strongest agency has been the personal influence of devoted men. It has made no effort to give professional training. It has made no pretense of leading in scientific research. A log with Mark Hopkins at one end of it and himself at the other was Garfield's conception of such a college. Even the log is not essential. The earnest teacher is all in all. Apparatus Mark Hopkins did not need, books he even despised. The medium of a forgotten language and an outworn philosophy served him as well as anything else in impressing on his boys the stamp of his own character. It was said of Dr. Nott of Union College that 'he took the sweepings of other colleges and sent them back to society pure gold.' Such was his personal influence on young men. A notable example of the college spirit was Arnold of Rugby. Another was Jowett, master of Baliol. A teacher of this type in greater or less degree it was the privilege of every college student to know, and this knowledge still reconciles him to his *alma mater,* however many her shortcomings in subject or method. But times have changed since the days of Mark Hopkins. The American college, English born and English in tradition, under the touch of German

influences and in response to actual needs, is changing to the American university. It is no longer a school of culture alone, a school of personal growth through personal example. It is becoming in addition to this a school of research, a school of power. It stands in the advance guard of civilization, responsive not to the truth of tradition alone, but to the new truth daily and hourly revealed in the experience of man.

In the movement of events the American university unites in itself three different functions, that of the college, that of the professional school and that which is distinctive of the university.

The college is now as ever a school of culture. It aims to make wise, sane, well-rounded men who know something of the best that men have thought and done in this world, and whose lives will be the better for this knowledge. It has not discarded the Latin, Greek and mathematics which were so long the chief agents in culture, but it has greatly added to this list. It has found that to some minds at least better results arise from the study of other things. Culture is born from mastery. The mind is strengthened by what it can assimilate. It can use only that which relates itself to life. We find that Greek-mindedness is necessary to receive from the Greek all that this noblest of languages is competent to give. We find for the average man better educational substance in English than in Latin, in the physical or natural sciences than in the calculus. But more important than this, we find that it is safe in the main to trust the choice of studies to the student himself. The very fact of choice is in itself an education. It is better to choose wrong sometimes, as we do a hundred times in life, than to be arbitrarily directed to the best selection. Moreover, so far as culture is concerned, the best teacher is more important than the best study. It is still true, as Emerson once wrote to his daughter, that 'it matters little what your studies are; it all lies in who your teacher is.' A large institution has many students. It has likewise many teachers, and an Arnold or a Hopkins, a Warner or a Thoburn, can come just as close to the students' hearts in a large school as in a small one. But 'the knowing of men by name,' the care for their personal lives and characters, must be the essential element in the new college course, as it was in the old. And the college function of the university must not be despised or belittled. Because Germany has no colleges, because her students go directly from the high school at home to the professional school or the university, some have urged the abandonment by the American university of this primal function of general culture. In their eagerness to develop advanced work, some institutions have relegated the college function almost solely to tutors without experience, and have left it without standards and without serious purpose. It is not right that even the freshmen should be poorly taught. On the soundness of the college training everything

else must depend. In the long run, the greatest university will be the one that devotes the most care to its undergraduates. With the college graduation higher education in England mostly stops. With Germany here the higher education begins. Higher education has been defined as that training which demands that a man should leave home. It means a breaking of the leading strings. It means the entrance to another atmosphere. The high school and the gymnasium cannot have the academic atmosphere, however advanced their studies may be. They must reflect the spirit of the town which supports them and of which they are necessarily a part. They cannot be free in the sense in which the universities are free. A boy who lives at home in a city and goes back and forth on a train cannot be a university student. He may recite in the university classes, but there his work ends. He gets little of the spirit which moves outside of the class room. He cannot enter the university until he breathes the university atmosphere. The 'Spurstudenten' or 'railway students,' those who come and go on the trains, are rightly held by their fellows in Germany to be little more than Philistines. Whatever the other excellencies of the German system, the gymnasium, or advanced high school, is an inadequate substitute for the American college.

The second function of the university is that of professional training. To the man once in the path of culture this school adds effectiveness in his chosen calling. This work the American universities have taken up slowly and grudgingly. The demand for instruction in law and medicine has been met weakly but extensively by private enterprise. The schools thus founded have been dependent on the students' fees, and on the advertising gain their teachers receive through connection with them. Such schools as these stand no comparison with the professional schools of Germany. Their foundation is precarious, they can not demand high standards, nor look beyond present necessities to the future of professional training. Only a few of these schools to-day demand high standards. Those who do not can not share the university spirit. They have no part in university development. Only in the degree that they are part and parcel of the university do they in general deserve to live. The first profession to become thus allied is that of engineering, thanks to the wisdom that directed the Morrill Act. Following this, law, medicine, theology, education in some quarters, have taken a university basis, and the few professional schools in which such a basis exists rank fairly with the best of their class in the world.

The crowning function of a university is that of original research. On this rests the advance of civilization. From the application of scientific knowledge most of the successes of the nineteenth century have arisen. It is the first era of science. Behind the application of

such knowledge rests the acquisition of it. One Helmholtz, the investigator, is the parent of a thousand Edisons, the adapters of the knowledge gained by others. The great function of the German university is that of instruction through investigation. The student begins his work on a narrow space at the outer rim of knowledge. It is his duty to carry the solid ground a little farther, to drive back ever so little it may be the darkness of ignorance and mystery. The real university is a school of research. That we possess the university spirit is our only excuse that we adopt the university name. A true university is not a collection of colleges. It is not a college with an outer fringe of professional schools. It is not a cluster of professional schools. It is the association of scholars. It is the institution from which in every direction blazes the light of original research. Its choicest product is 'that fanaticism for veracity' as Huxley calls it, that love for truth, without which man is but the toy of the elements. Its spirit is the desire 'to know things as they really are' which is the necessary attribute of 'him that overcometh.' No institution can be college, professional school and university all in one and exercise all these functions fully in the four years which form the traditional college course. To attempt it is to fail in one way or another. We do attempt it and we do fail. In the engineering courses of to-day we try to combine in four years professional training with research and culture. This can not be done, for while the professional work is reasonably complete, culture is at a minimum and research crowded to the wall. The subject of law requires three solid years for professional training alone. Three or four culture years go with this and are surely none too many. The same requirement must soon be made in engineering. We can not make an engineer in four years if we do anything else for him, and there are very many things besides engineering which go to the making of a real engineer.

But this we can do in the four years of college culture. We can show the student the line of his professional advancement and can see him well started in its direction before he has taken his first degree. We can give in the college course something of the methods and results of advanced research. In any subject the advanced work has a higher culture value than elementary work. Thorough study of one subject is more helpful than superficial knowledge of half a dozen. To know one thing well is in Agassiz's words 'to have the backbone of culture.' By limiting the range of individual training to a few things done thoroughly it is possible to give even to the undergraduate some touch of real university method, some knowledge of how truth is won. To accomplish this is one vital part of the university's duty. It welds together the three functions of a university, and in so doing it will give the American university its most characteristic feature.

The best education for any man with brains and character should involve these three elements. It should have the final goal in view as soon as possible. It should be broad enough and thorough enough to develop cultured manhood and at the same time to furnish the strength needed to reach this goal. In other words, it should look to success in the profession and to success as a man. Toward both these ends the methods of finding the truth for oneself are vitally essential. The university should disclose the secret of power, and this secret lies in thoroughness. Science is human experience tested and set in order. The advance of science has come through the use of instruments of precision and methods of precision. Opinion, feeling, tradition, plausibility, illusions of whatever sort, disappear when the method of power is once mastered.

The college course should have a little of the professional spirit for its guidance, a little of the university spirit for its inspiration; the best interests of all three will keep them in the closest relation to each other. At the same time they must not starve each other. At the present time the needs of the college in most cases tend to dwarf the more costly functions of the university. The professors have their hands full of lower work. The books and material the university work demand are far more costly than the college can afford. The trustees still too often regard the graduate school as an expensive alien, and its demands in most quarters still receive scant attention. To train fifty investigators costs more than to give a thousand men a college education. The sciences cost more than the humanities, and the applied sciences, with their vast and changing array of machinery, are most expensive of all.

Equally unwise it seems to me, though less common, is the disposition to slight the college course for the sake of advanced research. Poor work, wherever done, leaves its mark of poverty. The great university of the future will be the one which does well whatever it undertakes, be it high or low. Better have few departments, very few, than that any should be weak and paltry. Better few students well taught than many neglected.

It is fair to judge a university by the character of its advanced work. Institutions can not be graded by the number in attendance. This is the most frequent and most vulgar gauge of relative standing. The rank of an institution is determined no more by the number of its students than by the number of rocks on its campus. What sort of men does it have and what are they doing? These are the living questions. Buildings are convenient; beautiful buildings have a great culture value. We should be the last to underrate the effect of the charm of cloisters and towers, of circles of palms and sweet-toned bells. But these do not make a university. Books are useful, they are vital to

research, but wiser men than we have ever known have grown up without books. Shakespere had few of them, Lincoln had but few of them, Homer and Jesus, none at all. Books serve no purpose if they are not used. The man who reads it gives the book its life. Specimens are inevitable in natural history. Apparatus is necessary in physical science. Collections and equipment are really the outgrowth of the men that use them. You can not order them in advance. Professor Haeckel once said bitterly that the results of research in the great laboratories were in inverse proportion to the perfection of their appliances. An investigation may be lost in multiplicity of details or in elaboration of preparation. Some men will spend years in getting a microscope or a microtome just right and then never use it. It is said that the entire outfit of Joseph Leidy, one of the greatest of our microscopists, cost just seventy-five dollars. It was the man and not the equipment that made his investigations luminous.

Publication is necessary, but it would be the greatest of mistakes to measure a university by the number of pages printed by its members. Much of the so-called research even in Germany is unworthy of the name of science. Its subject matter is not extension of human experience, but an addition to human pedantry. To count the twists and turns of literary eccentricity may have no more intellectual significance than to count the dead leaves in the forest. Statistical work is justified not by the labor it requires, but by the laws it unveils. Elaboration of method may conceal the dearth of purpose. Moreover, it is easier to string the web of plausibility than to recover the lost clue of truth. Of a thousand doctor's theses each year scarcely a dozen contain a real addition to knowledge. In too many cases a piece of research is simply a bid for notice. American universities are always on the watch for men who can do something as it should be done. Work is often done solely to arrest the attention of the university authorities. A professorship once gained, nothing more is heard of research. The love of novelty with the itch for writing often passes for the power of original research. The fanaticism for veracity has nothing in common with versatile writing or paradoxical cleverness. It took Darwin twenty-five years of the severest work before he could get his own leave to print his own conclusions. Other writers put forth sweeping generalizations as rapidly as their typewriters can take them from dictation. In certain works which have arrested popular attention, the investigations must have gone on at the highest speed attainable by the pen of the gifted author. Such work justifies Fechner's sarcastic phrase, 'cuckoo's eggs laid in the nest of science.'

The work of science is addressed to science, no matter if half a dozen generations pass before another investigator takes up the thread. The science of the newspapers is of quite another type, and so is much of the

science of famous men from whom newspaper science derives its inspiration.

While the university on its human side is interested in all that touches the life of to-day, on the scientific side it deals with the eternal verities and cares nothing for those things which are merely local or timely.

The university must conduct research to ends of power. This it has hardly begun to do in America. Half our graduate students are not ready for anything to be called investigation. They are not real students of a real university. The graduate departments of our universities are now engaged almost exclusively in training teachers. That profession may be the noblest—where noble men make it so—but it is only one of many in which success must rest on original investigation. We are proud of our crop of Doctors of Philosophy, dozens or hundreds turned out every year. But most of them are trained only to teach, and we know that half of them are predestined to failure as college teachers. We must broaden our work and widen our sympathies. We must train men in the higher effectiveness in every walk in life, men of business as well as college instructors, statesmen as well as linguists, shipbuilders as well as mathematicians, men of action as well as men of thought. This means a great deal more than annual crops of Doctors of Philosophy to scramble for the few dozen vacant instructorships open year by year.

But with all these discouragements original research is the loftiest function of the university. In its consummate excellence is found the motive for its imitation. There is but one way in which a university can discharge this function. It can not give prizes for research. It can not stimulate it by means of publication, still less by hiring men to come to its walls to pursue it. The whole system of fellowships for advanced students is on trial with most of the evidence against it. The students paid to study are not the ones who do the work. When they are such they would have done the work unpaid. The fellowship system tends to turn science into almsgiving, to make the promising youth feel that the world owes him a living.

All these plans and others have been fairly tried in America. There is but one that succeeds. Only those who do original work will train others to do it. Where the teachers are themselves original investigators devoted to truth and skilful in the search for it,—men that can not be frightened, fatigued or discouraged,—they will have students like themselves. To work under such men, students like-minded will come from the ends of the earth. It is the part of the investigators to make the university as the teachers make the college. There never was a genuine university on any other terms. It is not conceivable that there should ever be one. It is not necessary that all depart-

ments should be equal to make the university real. It was enough at Harvard to have Agassiz and Gray, Lowell, Goodwin and Holmes to justify the name of the university. Silliman and Dana made a university of Yale. Such men are as rare as they are choice, and no university faculty was ever yet composed of them alone, and none ever yet had too many of them. President Gilman has wisely said:

> In the conduct of a university secure the ablest men as professors regardless of all other qualifications excepting those of personal merit and adaptation to the chairs that are to be filled. Borrow if you cannot enlist. Give them freedom. Give them auxiliaries. Give them liberal support. Encourage them to come before the world of science and of letters with their publications. Bright students soon to be men of distinction will be their loyal followers and the world will say amen.
>
> The merit of a university depends on the men who are called to conduct it, upon them absolutely if not exclusively, for although the teacher must have such auxiliaries as books and instruments, books are nothing but paper and ink until they are read, and instruments but brass and glass until craft and skill are applied to their handling.

But it is in its men that the real university has its real being. Through the work of such men it stands in the vanguard of civilization. By such men it counts the milestones in its course, and no trick of organization, no urging of the printing press, no subsidy of students can be made to take their place.

A final word as to the practical side of advanced research. Mr. Carnegie once ascribed the foundation of his great fortune to the fact that he first employed trained chemists where other manufacturers chose workmen skilled in making steel by rule of thumb. His chemists were able to suggest improvements. They devised ways of making better steel, cheaper still, and at the same time of utilizing the refuse or slag.

In the future the success of each great enterprise must depend on the improvements it makes. The nation successful in manufacture and commerce will be the one richest in labor-aiding devices. All these must depend on the advancement of knowledge. Pure science must precede applied science.

Once the manufacturer or the nation could employ its chemists as it needed them. Now it must make them. The advancement of any branch of science depends on the mastery of what is known before. Everything easy and everything inexpensive has been found out. To train the chemist of the future, we need constantly finer instruments of precision for his advanced work; access to greater and greater libraries that he may know what is already done, for each generation of scientific workers must stand on the shoulders of those gone before, else it can make no progress beyond them. The scholars of to-day would be helpless were it not that they can save time by drawing freely on the accumulated knowledge of the past.

To learn the elements of any science costs little. It can be learned at one end of a log with a great teacher on the other. It can be even learned without a teacher. But to master a science so as to extend its boundaries—this is quite another thing. More than a man can earn in a lifetime it costs to make a start—for this reason a university which provides means for such work is a very costly establishment; for this reason the investigator of the future must depend on the university. The nation with the best equipped universities will furnish the best trained men. On the universities the progress in manufactures and commerce must depend. Through the superiority of training Germany is passing England in the commercial world in spite of her handicaps of position and history. Through the excellence of her universities, without most of these handicaps, America is likely to excel both Germany and England.

As men of science are needed, they can not make themselves. Those with power can help them. This fact has given the impulse to the far reaching gifts of Stanford, Rockefeller, Carnegie and Rhodes. These are not gifts but investments, put to the credit of the country's future. The people too have power. The same feeling of investment has led them to build their state universities and to entrust to them not only the work of personal culture, but of advancement in literature, science and arts. With general culture and professional training must go the advancement of knowledge, the progress of society, through the advancement of the wisdom and the power of man.

SOME OBSERVATIONS ON THE BEHAVIOR OF THE SOCIAL WASPS.

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LITTLE has been published concerning the social wasps since de Saussure wrote so interestingly of them nearly half a century ago. His work is justly regarded as a classic, but unfortunately it has become so rare that, nowadays, it is inaccessible to the average student, and accurate knowledge of the group, save that derived from an occasional disagreeable encounter with one of its members, is meager indeed. Moreover, the wonderful ingenuity displayed here, and among the highest Hymenoptera, the care for the young, and provisioning against the rainy day have served, not only to point a moral, but to credit these forms with an intelligence second only to the human. Even those who adopt a purely mechanical explanation of animal activities are inclined to except the bees and wasps. Mr. E. L. Thorndike, in his general conclusions concerning the nature of animal intelligence, makes reservations in favor of this group, while Mr. and Mrs. G. W. Peckham, in their admirable study of the solitary wasps, contrast them with the social wasps in the following terms:

> The social Hymenoptera are born into a community and their mental processes may be modified and assisted by education and imitation, but the solitary wasp (with rare exceptions), comes into the world absolutely alone. . . . It must then depend entirely upon its inherited instincts to determine the form of its activities and, although these instincts are much more flexible than has generally been supposed and are often modified by individual judgment and experience, they are still so complex and remarkable as to offer a wide field for study and speculation.

The conclusions noted here, derived from the study of a group which is among the more primitive social Hymenoptera, may then be of interest as contributing somewhat to problems which are receiving anew the attention of both the naturalist and the comparative psychologist.

General Account.

In the tropics of the Old and New World, the family of social wasps or Vespidæ comprises seven genera, but only three of these, *Polistes*, *Polybia* and *Vespa* are represented in the United States. Of these, *Polybia* is the smallest and rarest, being restricted to California and Florida; *Vespa* is widely known as our common hornet or yellow-jacket,

while *Polistes* is smaller and more timid and its colonies never reach such formidable dimensions as those of *Vespa*.

Here, as in the other genera, the colony consists of three kinds of individuals—males, females and workers or neuters, and is founded usually* by a single female somewhat improperly called the queen. She, with perhaps several other females, is the sole survivor of a colony of the previous season, and has passed the winter in some warm crevice or sheltered corner. During the first warm days of spring, she may be seen seeking a suitable nesting-place and, this found, she begins the construction of the nest, which has the appearance represented in the accompanying figure. Each cell contains an egg suspended near its apex by the aboral end, and in the course of a few days this egg develops into a worm-like feeding larva. The queen works incessantly when the weather permits, increasing the number of cells, lengthening the cells already there and strengthening the stalk which supports the whole, so that when, at the end of six weeks—the first workers emerge, the nest may comprise as many as forty or fifty cells. From this time the workers gradually assume all the duties of the colony except the egg laying,† though, as far as I have observed, in a spirit‡ far different from that of the queen. Thus, one nest, which at the beginning of July was made up of forty-three cells, and represented the work of a single queen or mother, contained at the end of the season only one hundred and twenty-seven cells, the eighty-four additional cells being presumably the product of at least fifty workers which had emerged during the summer months. Toward the latter part of August and early September the males and females appear, and the nests are more and more deserted for the flowers and fruits of autumn. Here the males and females mate, the workers and males linger through the warmer days, while the fertilized females alone survive the winter and lay the foundation of the new colony in the spring.

The Site of the Nest.

This varies for different localities and to a certain extent in different species. In Wisconsin, where most of these studies were made, the

* The queens usually work singly, but in three cases two wasps were observed associating in the construction of the same nest. These may have represented a queen and a worker that had accidentally survived the winter. It is difficult to see how a partnership of queens could be formed, since the owner of a nest strongly resents the intrusion of another wasp, expelling her from the scene with the utmost ferocity.

† The careful researches of Siebold and Marchal show that even this function is assumed by the workers in case of the death of the queen.

‡ In writing a paper of this nature it is somewhat difficult to avoid misleading 'anthropomorphisms,' and it may be well to state once for all that the occasional use of expressions similar to the above is purely figurative and for the purpose of avoiding awkward circumlocutions.

preference seems to be for the sloping under side of old roofs, eaves and the protected casements of windows. Indeed, so strong has been the attachment to certain sites, that I have several times seen the wasps suspending one comb from another in the style of architecture characteristic of the hornet. In New England *P. pallipes* builds in the open on wild rose bushes and other low shrubs, in protected recesses of stone walls, while a tin can, a water pipe perforated by rust and a sheep's skull are other nesting places which have come to my notice. At Willow Grove, Pa., great numbers have made use of the space enclosed by the sheet-iron water-table of a new car barn, thus securing a maximum of warmth and immunity from the zealous wasp hunter. In Texas, I am told, certain species build on the cacti, while others prefer stone ledges; and doubtless further observation will disclose many other interesting variations in the nesting habits.

The Nest and its Construction.

The nest, as is well known, consists of a single layer of hexagonal paper cells. It is modeled from a soft gray pulp which is a mixture of fibers of weather-worn wood and a secretion from the wasp's mouth. The little ball of semi-fluid pulp is applied roughly by means of the fore legs, all along the edge of the cell to be extended, making an irregular addition about four times as thick as the cell wall. The wasp then walks back and forth for two or three minutes continually touching the material with her antennæ, and with her mandibles pats and smooths it into shape. This operation extends the wall each time from one eighth to one fourth of an inch, depending of course on the size of the ball of material at the beginning. In addition to this, the wasp applies a glutinous secretion which renders the paper tough and waterproof, the nests built in the open being more thickly coated than those sheltered from the rain and dew.

The geometrical sense of the bees and wasps has long been a matter of controversy. In *Polistes,* so far as I have observed, the first cells always approach a circle in cross-section, and the six-sided form is the result of the flexibility and the consequent compressing of the walls. Once pressed into shape, the material added may take the same form, and the artificer appears to possess a superior mathematical sense; but that the cells are not intentionally fashioned thus may be seen by examining those first formed, or those comprising the margin of the nest at any later stage of construction. These are always circular in outline.

The Care of the Young.

The larvæ, which develop in a few days from the eggs, are fed from this time until the beginning of the pupal stage both with nectar and proteid matter. The nectar is obtained from flowers, is stored for a

time in the crop of the mother or the nurse, and then regurgitated into the mouth of the larvæ. This process may be easily watched in the case of captive wasps. They nearly always make the round of the cells containing feeding larvæ some minutes after partaking of the sugar solution provided as their store of food. The animal food consists of caterpillars which have been worked by the mandibles into a mass about the consistency of marmalade.

This wasp does not sting her prey. Her habit is to seize the squirming caterpillar in her fore legs, pass it back and forth several times between her mandibles until it is quite limp and dead, and then to roll it deftly into a ball and hold it between the fore legs while she flies to the nest. There, the operation is continued three or four minutes longer, until the malaxation is complete. In distributing the food, the mass is held firmly against the ventral side of the thorax, by means of the femora of the first pair of legs and a bit partly pinched off with the mandibles. Next, the wasp inserts her head into a cell, lightly touches the larva with her antennæ, causing it to stir and open its mouth, and then pushes the bit of food into the mouth with the tarsal joints of the fore legs. With the remainder, the wasp now passes to another cell and the process is repeated until the ball of food is used up. Observations on the social Hymenoptera indicate that the polymorphism occurring here is in large measure dependent on the kind of food given to the larvæ. So far I have no evidence that *Polistes* exercises any selection in the quality or amount of food furnished the larvæ which are to develop into the various members of the wasp community.

The foregoing constitute the chief activities of *Polistes,* but several other minor performances may be briefly noted. Among these are the stroking and rubbing movements which serve to keep the body clean. They are chiefly six in number: (1) Hanging by the four posterior legs, while doubling the first pair backward over the head and repeatedly passing them forward over the face and antennæ. The latter are thus drawn between the tibiæ and the spurs which these bear on their distal ends. (2) Drawing the first pair of legs alternately between the mandibles, and thereby removing any foreign substances accumulated by them during the first step of the process. (3) Doubling the first pair of legs as above mentioned and passing them backward over the dorsal surface of the thorax and the bases of the wings. (4) Hanging by the two anterior pairs of legs and passing the hindmost pair backward over the abdomen and the folded wings. (5) Suspending the body by the first pair of legs and drawing each of the others in turn between the tibial spurs of one of the remaining legs. (6) Drawing the wings alternately on each side between the abdomen and the hindmost leg of that side. These are sometimes gone through in the order given, but not necessarily so; some of the steps may be altogether

omitted, although the movements of the anterior usually precede those of the posterior appendages.

Then the wasp makes frequent careful inspection of the cells of her nest. She may return every few minutes in the interval of her other activities apparently for the sole purpose of satisfying herself that all is well. To test the wasp's power of observation I have several times cut away a bit of the cell wall. In one case, the mutilation was immediately detected and an attempt made to repair the breach. Once, one of the eggs was replaced by one from another nest. When, in the course of the customary examination, this cell was reached, the wasp paused, gazed long and fixedly, as if unable to believe the evidence of her senses, and then with signs of great agitation, cleaned the cell out and deposited a new egg of her own. To ascertain whether the mucilage by which the egg was attached was the exciting cause, several eggs were smeared with it and left in their original positions. In this case the mucilage was carefully removed, but the eggs were left untouched.

Polistes is said also to store honey in the cells from which the perfect imagines have emerged. In the height of the season these cells are used a second time for the development of the young. They are then carefully renovated before the egg is deposited. I have never yet found honey stored in the nests taken, but in two nests which were kept indoors for the purpose of experimentation, many of the cells were found to contain a few grains of perfectly transparent sweetish substance which undoubtedly had been elaborated from the sugar solution forming the food store of the little colony.

The Larval and Pupal Periods.

The sole activity of the young during the three weeks' larval period appears to be the feeding on the elaborated nectar and proteid matter furnished by the mothers or the workers. At the end of this time the larva spins a silken lining and a covering for its cell. This is done by passing the head from point to point of the cell wall while a glairy fluid issues from its mouth and hardens into a delicate silken thread. I have noticed a considerable difference in the form of the cell covering. Under normal conditions, the cell is lengthened by the workers or queen to suit the increasing size of the larva, but in captivity the wasps cease the work of construction though they may still continue to feed the larvæ. The cell is therefore too short for the full-grown larva. In such cases it not only lines the cell but extends the wall with the same silken substance, finally capping it with a dome-shaped cover. This apparent forethought on the part of the larva is entirely accounted for, when we see that in spinning its cocoon the larva begins near the bottom of the cell, gradually approaches its mouth and finally stretches as far as possible beyond it. If the cell wall is already sufficiently

extended, this serves solely as a lining, if not, as, in part, extension to the original cell, providing the space necessary for the metamorphosis.

During the three weeks of the pupal period the pupa is quiescent, except for occasional twitchings of the abdomen. About two days before emergence the muscles of the appendages begin to undergo periodic contractions, which carry the pupa to the end of the cell, and rotate it to some degree. At the same time the jaws become functional, and the continued action results in the removal of the lid of the cell and the emergence of the wasp to assume its share in the duties of the wasp community.

Behavior of the Newly Excluded Worker.

The study of the newly excluded wasp is extremely interesting and throws some light, I think, on the character of its mental activities. There is at the outset considerable variation observable in its actions. Sometimes the little worker does not take the trouble to cut the lid of its cell entirely away, occasionally it not only cuts away the lid, but neatly trims the edges of the cell, and very rarely it pushes its head into the cell, as if to satisfy a curiosity concerning the place whence it has come, even making comparisons from the contents of neighboring cells. But I question whether this performance is rewarded by any intelligence.

Emergence accomplished, there ensues a period of quiescence, which for the most part is passed on the back of the nest, and which is probably necessary to the proper hardening of the tissues. Meanwhile the queen does not cease her labors, but makes it her first duty to clean out the cell left vacant by the newly excluded imago and lay an egg in it. Returning, perhaps, a little later with a ball of food, she thrusts it into the face of the worker, but no notice is taken of it, and she proceeds alone with the work of malaxation and distribution. This may be repeated several times before the young worker finally accepts the urgent invitation to take up its family responsibilities. There is no doubt that the worker sees what the queen is doing, and when, after apparently watching her go through the process of malaxing and dispensing the food several times, it comes up to take part of it and do the same, the inference is perfectly natural that the worker is imitating its mother. This idea is strengthened when we observe that it takes the young one about three times as long as its mother, to accomplish the task of feeding, and that there is great uncertainty displayed in offering the food to the larvæ. The young worker is apt to waste much time in poking its head into the wrong cells, and running unnecessarily about over the face of the nest.

To test whether the worker learns to do its work by imitation, I removed one nest, whose founder was missing, to a place half a mile distant from any known nest before any of the workers had emerged.

After the appearance of four workers, fresh caterpillars were repeatedly offered them. Two weeks passed before this met with any response, whereupon one day they all surprised me by coming up and very eagerly preparing and distributing the food. I have since made sure that the nursing habit is entirely independent of the example of the mother and, further, that its appearance is to some extent variable for different individuals.

In the experiments conducted the past summer, bits of the larvæ of the Ribbed Rhagium, a beetle whose eggs develop under the bark of decaying trees, were offered at intervals to the newly excluded neuters before they had had any association with others of their kind. With slight exception, great trepidation, or rather movements which I interpret as indicating fear, was shown at the first appearance of the morsel. The wasp retreated precipitately from the proffered morsel, sometimes turning and running away in the wildest manner imaginable. But usually when the bit had been presented for the fourth or fifth time (at intervals of one half to one minute), the wasp would no longer back or run away, but stop and look at it. The next action was to touch it with the antennæ and finally it was seized and disposed of in the customary manner. Usually the experiment met with success in the way described if performed any time after the first half day of imaginal life. But I have seen a worker not four hours old spontaneously go through the same reaction while others waited several days before manifesting the instinct.

The whole process seems to be a reflex called forth by the presence of the food, and an important factor in calling it forth is hunger on the part of the wasp. It is highly probable that in the crushing process liquids are extracted from the mass, which are swallowed by the wasp. I have frequently seen them *chew at* morsels without molding or mixing them, and even dropping the mass to lap up the liquid which had exuded from it. Once started, however, the reflex unfolds in the natural order, first the crushing and molding, then a slow marching round the nest with frequent pauses, and, if larvæ are present, the pinching off of the food bit by bit until all has been disposed of. If no larvæ are present, if, for instance, the young worker is living in an inverted tumbler and has never seen a larva the various stages in the process are the same. It will run searchingly over the glass and pause every few seconds to thrust the ball against it. This naturally meets with no success and the food is again worked over and the process repeated, perhaps several times, before the bit is dropped and not again noticed. Very rarely the wasp will attempt to fly with its burden, although naturally, since it has had no association with a nest or larvæ, it flies nowhere in particular. These observations remind one strongly of Faber's experience with the mason-bees which, when their half-built

nest was replaced by one that was finished, went on building until it was half again as high as it should have been. In *Polistes* it seems that the very success with which these first unfoldings of the feeding instinct meet, serves to stamp it into a useful habit. If the worker is at home, with the feeding larvæ at hand to seize the proffered bit, all goes well, and it becomes henceforth an efficient member of its community. But remove it, and so interfere with the normal unfolding of the reaction, and the wasp soon disregards the food altogether or contents itself with a few perfunctory turns and squeezes.

Not that the wasp has any idea of performing a service for the benefit of its kind. I have seen a young neuter gnaw a piece out of the side of a dead wasp larva fallen from its cell, and turning, offer it as food to the mouth of the self same larva. More than this, I once observed a neuter attack a live larva and, after she had cut out and crushed a fair-sized piece of its body, come back eight times in the course of her examination of the cells of the nest to this larva, which had naturally died in the operation, and offer it this part of its own body with the evident expectation that it would be seized and eaten. The eighth time she dropped the piece on the face of the dead larva and went away with an air of 'duty well done' which was comical to behold. There can be little doubt that the normal repetition of the reflex perfects it, so that finally the process is quicker and easier than at first; and in this sense the little worker learns, but thus far I have had no evidence that it gains anything by the example of its elders.

One other note on the feeding habit may be of interest. Throughout the social Hymenoptera the male is the drone of the colony and usually among the solitary wasps the work of excavating or otherwise constructing and storing the nest devolves entirely on the female. Mr. and Mrs. Peckham recount cases of cooperation of the male with the female of *Trypoxylon* to the extent of guarding the nest and even taking the spiders as they were brought by the female and packing them properly away. In one colony under observation this fall, the males eagerly took portions of dead larvæ from one another, and crushed and turned them in their mandibles; and, in one instance, when the malaxation was complete, one of them carried it over the nest in the same searching manner as the female, and finally fed it to a larva. This is the only recorded instance among the Vespidæ known tc me, but it is likely further careful observations would show similar aberrations of instinct.

The Locality Study.

Several days usually elapse before the young *Polistes* makes its first essay into the world. When it does appear, the impulse to fly is strong, though in most cases it soon spends itself. That is, if in captivity, the wasp will repeatedly beat itself against its prison walls and steadfastly

refuse to perform any of the reflexes it may have shown prior to this time. If at liberty, the impulse usually carries it a short distance, perhaps two or three feet from the nest, where it spends a considerable amount of time running about in an inquiring way. This alternation of short flights and strolls may last for an hour or more, and the wasp extends its examination of surrounding objects to some distance, before it returns leisurely and as if by accident to the nest. There is no such apparent purposefulness in the procedure as has been described for the solitary wasps.

The social wasps seem to fly because they feel like it, and the flight is not long because at first it is exhausting. Then follows rest and a stroll, because strolling is easier than flying; then, after another period of repose, perhaps another flight, until a period of this aimless wandering brings it back within reach of the distinctive odor of the nest, whereupon it returns to the accustomed place. Occasionally, the little wasp gets lost in these first casual ventures, and it is not improbable that some wasps become wanderers from the very beginning.

Unquestionably, being on the nest brings about a state of satisfaction analogous to that evinced by Mr. Thorndike's chicks when they had rejoined their mates. I have several times put a nest in a glass jar where wasps were confined, and when, after fifteen or twenty minutes' wild buzzing and running about, they accidentally came in contact with it, their behavior was, at once, entirely changed. They became quiet and observant, and soon showed a disposition to go on with their usual activities.

It is somewhat difficult to suggest to what this may be due. The nest has a faint characteristic aroma resembling that of wild honey, which becomes very perceptible when it is confined in a small space. Both the manner of using the antennæ and the behavior of wasps in which one or both of these organs have been excised indicate that sense perception by means of them is an important factor in orientation. Within certain limits, the odor of the nest may then serve to guide the wasp and modify its activities when it reaches home.

It may be profitable here to reflect on the factors of the extremely useful feeding habit. The whole appears to be a complex of reactions which are at first quite separate and distinct. The first step is the perfection of the process of malaxation and distribution of the food, and is taken before the wasp feels the impulse to leave the nest, or has had any opportunity of finding food for itself. Next comes the familiarizing with surroundings. This at first has apparently no relation to food-seeking, yet in course of time, and aided probably by the olfactory sense, the wasp naturally comes upon something edible, and, after extracting the juices, it may well be that it tries to distribute the food on the spot. This being impossible, there is a second alternative,

that is, to fly, and, if flight takes it back to the nest, the rest of the procedure is probably carried out. Repetitions of this chain of actions causes it to occur oftener and with greater constancy, until the habit in all its complexity is well established.

It is well known that usually the wasp flies straight out from the nest, and does not return by the path it took in leaving. And while it appears that the first 'locality studies' are the desultory wanderings just described, there are nevertheless circumstances where *Polistes* makes the swift survey of the objects surrounding her nest, which has been described by Mr. and Mrs. Peckham for many of the solitary wasps. I observed this in numbers of instances where the wasps were set free after having been left in captivity long enough to habituate themselves to their new surroundings.

One nest with four workers was brought into the laboratory and established in a large glass cylinder, with a supply of food and weather-worn wood, so that they might go on with their activities if so inclined. They soon ceased their attempts to escape, and by the end of a week were attending to the wants of the larvæ in the usual manner. The glass plate from which the nest was suspended, was then moved to one side so as to leave an opening of several inches, but the wasps not perceiving this after several trials, the whole was carefully lifted out and rested on two supports, so that the wasp would find itself free if it flew six inches in any direction. Following is an account of a typical locality study transcribed from my notebook:

11:10. Freed nest (way already indicated). One of the wasps has flown out from the nest, hovers above it at a distance of twelve inches, and rising to the ceiling hovers there for some seconds. During the next six minutes descends to hover and circle within six inches of the nest, and, a second time, comes within two inches, without, however, alighting on it. First, flies round with its head directed toward nest, then turning, circles with its head away from the nest. This performance is repeated, and at 11:10 it alights on the glass, from the under side of which the nest is suspended, and for twenty seconds it beats its head against the glass. Rising, it explores first the upper, then the middle section of the room. Rising to the ceiling once more, hovers there and then descends to rest on glass as before. Spends several minutes exploring the room, and, returning, hovers for a few seconds before dropping upon the nest.

This is a fairly representative procedure, though there is great individual variation in the number and character of the circlings and the amount of search necessary in finding the nest after the more distant parts of the room have been visited.

Although no lengthy series of experiments was carried out with the same individual, those that were made show a decrease in the number and minuteness of the circlings proportional to the number of times the wasp so left the nest. The wasp never returned to the nest along

the path by which she had left it. Experiments were also made by moving the nest as soon as the locality-study had been made, and seeing whether the wasp returned to the place where the nest had been. Invariably the wasp did return to the exact former site of the nest, but considerable variation was shown in the ability to find the nest in its new location. One wasp had no difficulty, when the nest had been moved a distance of eighteen inches; others were unable to do so if moved more than eight inches. In one instance, the site of the nest was changed while the wasp was sipping honey from a dish about fourteen inches away. Returning, and not finding its nest in the usual place, the wasp, in circling, reached the honey dish once more, and again started for the nest along essentially the same path. This was repeated eight times before the wasp in its explorations finally reached its nest and rested there. The whole performance looked as though the wasp were consciously using the honey dish as a landmark. It started out from this point each time, the same way as a person might, when he became aware that he was making some mistake in finding his way to a desired destination.

It would be interesting to speculate on the meaning of the various actions described above. What sense best serves *Polistes* in finding its way about? Does it actually see and make a mental note of the various factors of its environment? Or does a mere blind following in response to other sense impressions, namely, the olfactory, serve its purpose? Theory is fascinating, but with the slight data at command, it is hardly profitable. Observation shows that the wasp instinctively flies toward the light; its course is also materially affected by currents of air, such as draughts in a room where it is held captive. Mechanical response to these two influences will, in this case, usually serve to liberate it without the use of any other sense or faculty. Again, the antennæ seem to play an important rôle in orienting the insect. Accidental loss of one antenna in one case retarded the finding of the nest. Further, the flight in circles, when leaving or approaching the nest, might be interpreted as due to the difference in stimulation of the antennæ of the two sides—the side toward, and the side away, from the nest; and the flight straight to the nest, when the wasp has poised for a moment with both antennæ directed toward the nest, seems to add evidence in favor of this view. However, further experimentation is necessary before it is possible to attempt a satisfactory explanation.

During the cold days of autumn, when there are no more larvæ to rear, about the only activity observed on the nest is that occasioned by the home-coming of a member of the wasp family. This one is tumultuously set upon by the half dozen wasps nearest him, each of which is favored with an embrace which is amusingly like the affectionate demonstrations shown on the return of a human being to his family

fireside. Here, however, the attentions are lavished, not only on the newcomer, but on those who were the first to meet him, and plainly the meaning of the whole performance is simply the distribution of nectar by one of the wasps which has just returned from a foraging expedition. Earlier in the season, this nectar is regurgitated into the mouths of the feeding larvæ, but in their absence it is stored in the cells or serves directly as food for the adults.

Finally, I think the habits *Polistes* acquires may bear a decided relation to its rhythm of activity and repose. If we watch any wasp community, we see that periods of general sluggishness alternate with furies of activity and, in the case of the individual, any marked exertion is always promptly followed by great quiescence. Of course, what actually happens to the nervous system when impressions are fixed and habits formed is largely a matter of conjecture. But in the establishment of any reaction, it is generally thought that the repair of the nervous element is quite as important as the change which it undergoes while the reaction is taking place. And it would seem that the delicate nervous organization here implied would lend itself readily to the 'stamping in' of reactions or trains of reactions. That is, a particular performance, once called forth, would the more readily occur had a period of repose prevented the reception of any intervening impression and brought about the restitution of the nervous mechanism affecting the reaction in question.

The period of repose on the nest is usually terminated by one of the wasps starting up and commencing an examination of the cells of the nest. Others immediately follow suit, until the whole colony is in a tumult. But it is not the example of the first wasp that is responsible for this, only the external stimulus furnished the sleeping colony by the movements of the first wasp on the nest. Simple tests prove this. Godart relates how the colonies of *Bombus* have a trumpeter-bee, whose duty it is to rouse the colony to work in the morning. If this bee is removed, another takes its place the following day. An observer of a wasp colony might easily believe that similar duties had been delegated to particular wasps. But here, and probably in the case of *Bombus*, it is the fact that any external stimulus, such as a loud noise or jarring the nest, produces the same effect. The wasp examines the cells not because it is aroused to a sense of duty by seeing what the others are doing, but because this is the habitual response whenever it is gently stimulated while on the nest, by any means whatever.

In summarizing these observations, it may be said that, although they are perhaps hardly extensive enough to warrant definite conclusions concerning wasp intellection, they nevertheless indicate several things:

1. All wasps possess the instinct of fear. This is especially strong the first few days after emergence, but is readily overcome by the frequent appearance of the awe-inspiring object.

2. The feeding instinct is evidently called forth in response to olfactory impressions. These responses become more precise as they are repeated.

3. Once established, under favoring conditions separate reactions combine to form complex habits.

4. In a sense, the wasp remembers. This is indicated by the manner in which it accustoms itself to the sight of strange objects, and by its behavior when a change is made in its nest or surroundings.

5. It shows considerable individual variability, both as to time and manner of its response to stimuli.

6. Wasps do not imitate one another. Instinct and individual experience account sufficiently for their powers, and their apparent cooperation is due entirely to the accident of their being born on the same nest.

FIELD NOTES OF A GEOLOGIST IN MARTINIQUE AND ST. VINCENT.

By Dr. THOMAS AUGUSTUS JAGGAR,

U. S. GEOLOGICAL SURVEY AND HARVARD UNIVERSITY.

"So late as 1851, Mont Pelée burst forth furiously with flames and smoke, which naturally threw the people into a serious panic, many persons taking refuge temporarily on board the shipping in the harbor. The eruption on this occasion did not amount to anything very serious, only covering some hundreds of acres with sulphurous débris, yet serving to show that the volcano was not dead, but sleeping. Once or twice since that date ominous mutterings have been heard from Mont Pelée, *which it is confidently predicted will one day deluge St. Pierre with ashes and lava, repeating the story of Pompeii.*" M. M. Ballou in 'Equatorial America,' Houghton, Mifflin, *1892*.

THE extraordinary accuracy of the above prediction, printed ten years ago, has been forced upon the world's attention recently by the sad story that the newspapers have told of the volcanic disasters in the Caribbee Islands. The following notes and the accompanying illustrations were collected hastily in the field after a month spent in incomplete study of the two volcanoes and their effects. Such notes necessarily contain inaccuracies; they may be more accurate, however, than many of the fairy stories that have gained currency in the dailies, and if I succeed in correcting some false impressions that have gone abroad about the meaning of these eruptions from the scientist's standpoint, I shall accomplish all that is necessary prior to more complete and accurate publication as the product of laboratory research at home. When the first news of the explosions reached America the newspaper accounts proved marvelously accurate; when half a hundred correspondents reached the field the degree of accuracy waned—probably directly as the public interest, which needs fiction to keep it alive. It is to be hoped that when the magazine stage of recording the Caribbean eruptions is reached, the truth curve will rise once more and the facts assert themselves. Even here—I write from Barbados—the most remarkable statements are solemnly believed; victims were found with their intestines charred and the outer skin untouched; a man was found seated on the box seat of a carriage in a lifelike position, twirling his moustache; scientists assert that the whole island of Martinique is likely to blow up at any minute, and great rents traverse the island from end to end; St. Vincent is in flames, a hundred minor craters have broken out, not a living green plant persists on the island and vessels cannot land; Ameri-

can scientists say that these eruptions have no parallel in history, and the electrical and gaseous phenomena make them unique—these and a hundred other similar statements have absolutely no foundation in fact, while other most interesting details have passed unnoticed. The fault,

FIG. 1. ST. PIERRE: SHOWING THE AMERICAN CONSULATE AND THE CATHEDRAL AS THEY WERE BEFORE THE ERUPTION.

however, does not rest with the correspondent; it rests with those at home who 'cook up' cable despatches, and with those living in the islands whose nerves are gone and who are thereby in an overimaginative frame of mind. Thus while I was occupying a beautiful little villa under the leeward slopes of Soufrière, a small thunderstorm broke about

FIG. 2. ST. PIERRE: THE SAME GENERAL VIEW AFTER THE ERUPTION OF MAY 8, 1902.

midnight over the mountain—thunderstorms occurred nearly every day. It was described next day as follows in the local paper:

At about three o'clock in the morning, May 30th, whilst the moon shone in dazzling splendour, an enormous silvery cloud rose from the Soufrière, and immediately afterwards roars, which in all probability issued from the crater,

once again awed the inhabitants. The cloud ascended majestically to a great height and was lit at close intervals by flashes and streaks of red lightning. It is reported from Cumberland that ashes fell from the eruption this morning.

With such an account ten miles from the scene of action, it is not remarkable that the story has lost all semblance of truth when it reaches New York.

When the scientists were embarking on the *Dixie,* they were constantly asked 'Well, doctor, just what do you expect to do when you get to Martinique?' It was at that time a difficult question to answer, but may now be answered by telling briefly what we have done. The

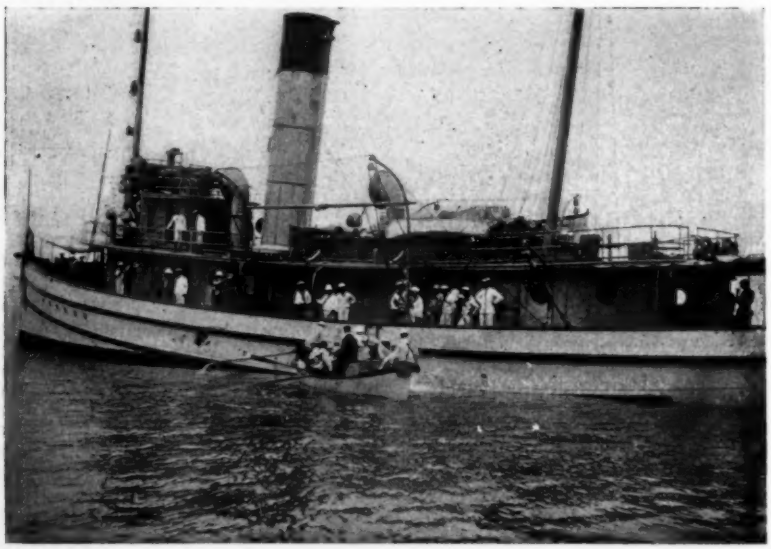


FIG. 3. ST. PIERRE: U. S. TUG POTOMAC IN THE HARBOR, MAY 19, 1902, starting to search for the remains of Consul Prentis.

Dixie arrived at Fort de France at daylight, May 21. At 10:30 that morning a party of officers, scientists and correspondents were taken on the *Potomac* to St. Pierre and landed. The second great eruption of Pelée had taken place the day before, so that every one was on the alert, and we were warned by Lieutenant McCormick, commanding the *Potomac,* that if the tug's whistle blew we were to make for the boats at once. We wandered through the dreary ruin, which has been described. I was impressed by the completeness of the destruction of the masonry and the absence of visible large volcanic fragments. The streets were filled with masonry rubble, mostly rounded sea-worn bowlders, and everything was coated with green-gray powder or sand. The roofs were gone, an occasional timber was burning, bodies were still numerous if

one went into the houses and looked for them. There was a baby in an iron cradle, a man face downward in a tank, and a man lying on his

FIG. 4. ST. PIERRE: RUE VICTOR HUGO, the main thoroughfare of the city, before the eruption.

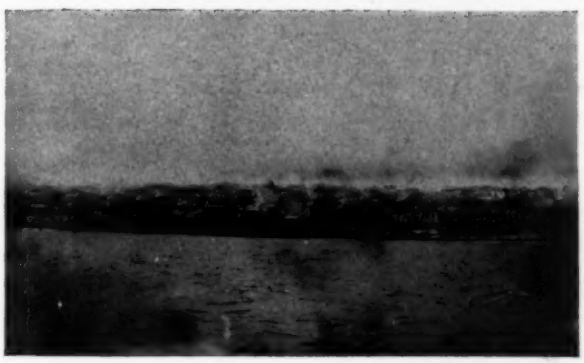
FIG. 5. ST. PIERRE: RUE VICTOR HUGO NOW.

back in a deep baker's oven. One of the party found eight or ten bodies crowded together at the foot of the cliff. The end of the town toward

the volcano is deeply buried under fallen sand or gravel—the southern end has a covering of only a foot or two. There is a great change in the aspect of the city now, since the later eruptions, from the condition shown by photographs immediately after the destructive blast of the eighth of May. It seems agreed by those who witnessed the eruptions that the explosion of the twentieth was greater than the first one. In any case, the second blast demolished third stories and leveled the second belfry of the cathedral—the heap of beautiful bells, the chimes 'whose soft, liquid notes used to ring across the water of the bay with touching cadence at the Angelus hour'—they lie tumbled in rubbish, splinters and steaming vapors, their ancient engraved inscriptions half buried in dust. The bodies found were mostly shriveled to a crisp—this too was in part the effect of the second hot blast of the twentieth, for many of the bodies found earlier were described as being not much altered, and some such are shown in the accompanying photographs. The odor was not especially bad, but it is a haunting smell that one dreams about afterward; it is a combination of foundry and steam and sulphur matches and burnt things, with every now and then a whiff of roast or decayed flesh that is horrible.

I had returned over the heaps of rubble along the Rue Victor Hugo, the main street parallel to the water front, to a point not far from the landing, and looked about me. It was impossible to realize that this ruin had been a thriving French city just one fortnight previous; literally not a roof was left the whole length of the city for two miles, and scarcely a timber; nothing but twisted iron and masonry and corpses. Here and there steam rose through little holes in the wet brown sand over a pile of cobbles, and a sickening whiff of it showed whence it came. I found a dead cow in a back stable-yard, and a lot of children's toys, and the dishes set on a dinner table; but one must needs search for these things. Almost everything is buried under fallen walls. The tropical architecture, almost wholly cobblestone masonry and pink plaster, with open courts, alleyways and inner gardens, strongly suggests Pompeii; a wooden New England town could not have persisted three hours in the presence of the giant blowpipe that destroyed St. Pierre; it would have been simply burned up and blown away as ashes. The timbers of St. Pierre are practically gone. I looked toward the gray old volcano, whose summit was shrouded, but the lower slopes were sunlit and silent and powdery; the whole landscape is powdery, like old statuary with a dust coating that makes stronger the modeling of the city; mountain slope and cliff are bare, the verdure of the Carbet hillside ends abruptly along a sharp line, and there begins the new volcanic landscape, clean chiselled, rocky, weird, gray, uniform, without any color, without any motion except steam-

jets on Pelée's slopes. But look! What are those steam-jets doing? There were one or two along the sea-front when we landed, but now there are eight, ten, twenty, and they are spurting higher all over the slope. Dr. Church was standing near me and saw me watching them. We did not either of us like the look of it. Now there were about forty, like so many ghostly locomotives that had run out from their tunnels in the volcano roundhouse and were all getting up steam at once. White-coated officers and men of science were to be seen in groups here



FIGS. 6, 7. ST. PIERRE: VIEWS OF THE CITY, showing the dust-covered ruins.

and there far away among the ruins and on the higher walls and slopes, but they were under the cliffs out of sight of Mont Pelée. We looked towards the *Potomac;* yes, she had seen it too, and a white steam-jet from her preceded the sharp blast of her fog-horn as she sent out a quick-repeated summons for all to return at once. Pell-mell they came tumbling to the water front and there was always someone else who had not turned up yet; the white-coated jackies were in place and the boats started from the shore. No sooner were they clear of the

FIG. 8. ST. PIERRE: INTERIOR OF A HOME. Woman, girl and boy. The living figure is Dr Haven, U. S. Consul at St. Kitts. Photograph taken May 19, the day before the second great eruption.

FIG. 9. ST. PIERRE: A VICTIM.

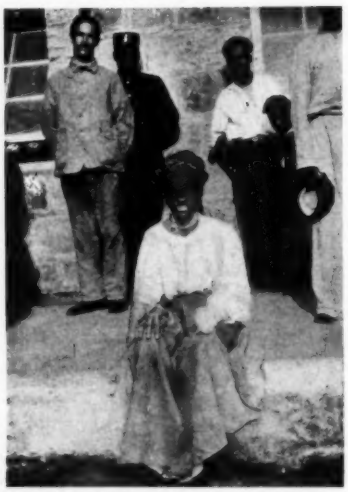


FIG. 10. ST. VINCENT: ONE OF THE INJURED.

landing than two more figures appeared and we had to put back for them. Meantime the mountain was sending up clouds of steam from all over its slopes as though it were rifting in a hundred places preparatory to a titanic outburst. But it did not do anything, and I now strongly suspect that what we saw was the product of a smart shower over the mountain from the clouds lowering on its summit. The cool water rills running down the slopes come into contact with beds of hot dry gravel previously thrown out. Wherever such a contact is made a jet of steam at once is formed; we had opportunity to see much of this action later on at St. Vincent, and it is this process that has given rise to many stories of small craters forming.

We spent another day among the ruins, exploring St. Pierre to the mountain slope at its northern end and to the steep roadways that climb the southern cliff. The city was in a *cul de sac,* hemmed in by a cliff south, a higher cliff east and the ocean west; its northern end was on the actual foot slope of the volcano. The present crater was blown clear of clouds as we steamed past and we saw a cup on the summit open to the west, walled in on the east, with a huge pile of scaly looking hot bowlders in its midst steaming violently. At the distance from which we saw it, it was estimated roughly that the cup would measure perhaps 2,000 feet across by 800 feet deep. This crater ends in a deep gulch west that extends down to the sea; old photographs show that this gulch was there before the present eruptions. Apparently it was down this gulch that the mud flood came which overwhelmed the Guerin factory. All along the foot of the mountain are steaming fan-shaped deltas of débris, and far up the slopes these are matched by leaf-shaped arroyos or deep trenches hollowed out of the old earthy volcanic beds of which much of the island is composed. This trenching has been accomplished by the cloud-burst torrents of water laden with grinding sand that fell during and after the eruptions—in part condensed steam and in part heavy rains that recently have been exceptionally abundant. Much of the material which fell in the first outbursts of probably both Pelée and Soufrière was dry and red hot; it was relatively fine, the largest fragments falling near the vent. The grades of the hillsides were already steep and it is probable that this material flowed somewhat like dry sand. This, if seen at night, would account for the reports current of glowing molten lava on Pelée. When I was in Martinique there was no sign of molten rock, nor have I seen any in St. Vincent, and the greater part of the evidence at present makes these eruptions purely steam explosions which have blasted out and comminuted large quantities of the old country rock, or bedrock of the islands, itself an ancient volcanic product.

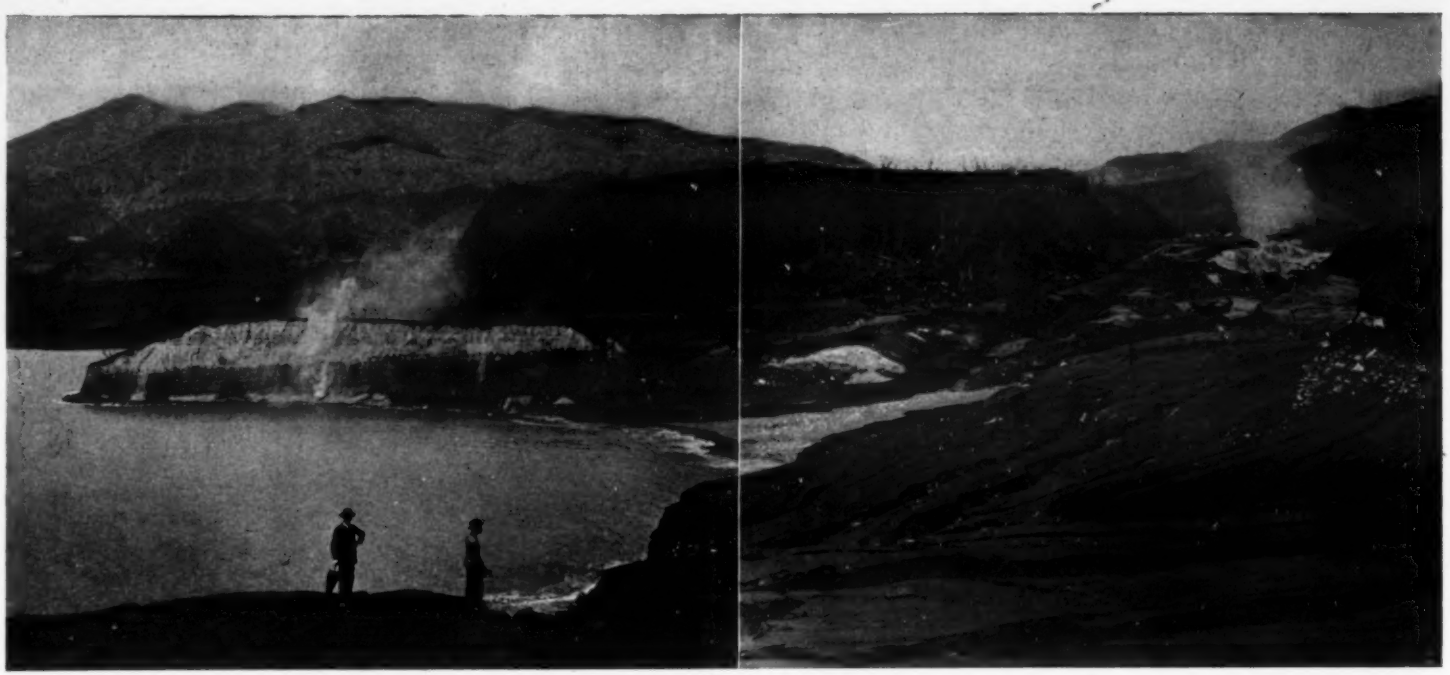


FIG. 11. ST. VINCENT: THE SOUFRIÈRE VOLCANO AND THE STEAMING GRAVEL BEDS OF THE WALLIABOU RIVER, LOOKING N. E. The steep sea-cliffs shown are the product of submarine landslips. Under the 45 feet of sand, gravel and boulders heaped in the foreground, Richmond Village is buried. This corner is the St. Pierre of St. Vincent in location and effect of the explosion. Note the coating of wet sand above the fiery gravels up the Walliabou and at its mouth. Photograph taken by C. Taylor of St. Thomas, May 31, 1902, the day of the ascent of the leeward slope; the climbing party were on the crater's edge when this picture was taken.

On the 23d of May the *Dixie* landed us and a goodly store of supplies for the sufferers, at Kingstown, St. Vincent. There I left her, in company with Dr. Hovey and Mr. Curtis. It was with deep regret that we parted from Captain Berry, whose splendid hospitality had made the entire voyage a pleasure that all the guests on the ship will never forget. It was really the first parting from American territory, for on a man-of-war one feels rather safer than on land. Good friends sprang up, however, among the hospitable English colonists, and supplies, houses, servants and horses were furnished us before we could ask for them. The government supply steamer *Wear* was on several occasions placed at our disposal, so that we coasted around three fourths of the shores of St. Vincent before going into the interior at all. We saw the Soufrière in partial eruption in clouds and rain; we landed at Georgetown on the fatal windward coast and visited the hospitals, where opportunity was given for interviews with the scorched victims of the explosive blast of hot cinders that had burned faces and ears and hands and feet, but curiously failed to burn clothing or houses. The hot sands, when they fell on these people, seem to have been at a temperature hot enough to inflict scalding wounds, but not hot enough to ignite anything or burn through coverings. On May 29 we proceeded in a long dug-out canoe rowed by five stalwart blacks to Chateau Belair, and from that point explored the west coast of the volcano proper and made a successful ascent to the edge of the great crater on a brilliantly clear day. The following week we made a similar ascent from the eastern or windward side, but reached the crater's rim in a most unpleasant black fog after a rather perilous climb along precipitous wastes. After two weeks of most instructive work at St. Vincent, I came to Barbados, ninety miles to windward, to learn something of the dust which fell here in showers on the evening of the Soufrière eruption. This completes the itinerary of the writer to this date.

The devastation at St. Vincent does not appear especially different from that at Martinique. The human conditions were different and the destruction of property wrought by the first eruption was much more widespread. In this respect, and from the size of the crater and greater diffusion of the dust, it seems certain that the Soufrière eruption was phenomenally much more violent than the eruption of Mont Pelée. The crater is more than twice as large as that crater of Pelée which I saw on May 21; the dust-fall has been reported from Trinidad, from Barbados, and from vessels at sea to the east and southeast at distances from one hundred to nine hundred miles from St. Vincent. At Walliabou sugar works southwest of the volcano, and in Richmond next to it, exactly the same fiery blast swept the cliff face as at St.

FIG. 12. ST. VINCENT: AVENUE IN CHATEAU BELAIR, showing the Soufrière in the distance Just outside of the destruction belt, on the west side of the island.

FIG 13. ST. VINCENT: AVENUE FROM RICHMOND HOUSE TO THE SUGARWORKS, one mile from Chateau Belair. Just within the destruction belt showing the ruin of Richmond House. In location Richmond was the St. Pierre of St. Vincent.

Pierre. In the same fashion Richmond is buried, 45 feet deep at its northern end, 3 feet at the southern. In the same way the one masonry building in Richmond village was thrown down, and five-foot blocks of masonry blown forty feet away from the mountain. The very odor over the ruin is the same. Just south of the Soufrière there is a group of high mountains. These blocked the passage to leeward southwest, and the heavier material thrown out of the crater's throat accumulated in the basin between these mountains and the volcano. Great drifts of fiery hot sand and gravel fell here and remained hot for weeks. The local torrential streams at the beginning of the rainy season, working on these beds, are converted into steam and make spectacular explosions, which alarm the natives, but are really quite harmless. At the sea-front west of the Soufrière there have been submarine landslips on a considerable scale, leaving in some instances vertical earthen walls 50 feet high where before there was a peaceful little village of thatched huts. The sea laps the foot of these unbalanced precipices, and a twelve-foot oar three feet from the strand-line finds no bottom. To a geologist one of the most remarkable effects of such an eruption is the rapid wearing away of the land that succeeds it. The protecting matter of tropical jungle has been burned and buried under two to ten feet of angular sand-grains; heavy rains cut torrent trenches in this material and all the old slopes are suddenly steepened by the falling away of the seashore and the piling of volcanic débris on all the crests of the land. The mountain is soaked in steam and water, local showers are at work all the time, and the result is like playing the hose on a steep mud pie; trenched and rill-marked in every direction, landslides are the rule in such topography and no slopes are safe. I landed for only a few moments to collect a specimen in one of the deep canyons northwest of Soufrière; a few blows of the hammer started a twenty-foot block of solid rock out of the gulch-slope a hundred yards away, and immediately afterwards a great bank of earth some twenty-five feet high came crashing down only a few feet from me. Needless to say I beat a hasty retreat to the boat from such an unstable land. We learned from this experience that the only safe place on new volcanoes is on the crest—unless one includes the Irishman's position, on 'leave of absence.'

There are a number of questions constantly asked of a geologist in this field, and some of these I must try to answer briefly here, without going further into a description of geological details. Was there any forewarning of the eruptions? Clearly there was; the prediction quoted at the head of this article was based on well-authenticated data. At Pelée, the lake in the crater was warm, and the smell of sulphuretted hydrogen perceived as far back as January. In April

FIGS. 14, 15. ST. VINCENT: THE U. S. S. DIXIE AT KINGSTOWN unloading supplies for refugees; one of the *Dixie's* lighters unloading on the beach at Kingstown; a camp of refugees, using the U. S. tents sent by the *Dixie*, and a hungry family waiting for 'government rations.'

there were noisy rumblings and steam was emitted; actual eruption is reported from April the twenty-sixth on, and yet the city was not evacuated. In St. Vincent local earthquakes have been on the increase for a year in the neighborhood of the volcano; people were actually frightened away from Windsor Forest on the northwest slope of Soufrière, as far back as May, 1901, by rumblings and quakings. The water of the lake has been seen to bubble and sulphurous coatings are described as being deposited on the rocks. So violent were the signals early in May, especially when the news of the Guerin disaster came from Martinique, that the leeward slopes of the Soufrière, at all times sparsely inhabited, were abandoned. Hence the small loss of life on that slope. On both islands, if the respective governments had maintained vulcanological stations with instruments, doubtless, there would have been perceived a gradually increasing series of signals of different sorts, tremors, sounds, sights, smells and temperatures. This record, if we had it now, would be invaluable. It cannot be reconstructed.

The question 'What actually happened in the eruptions?' involves no very great difficulty. The eruptions were small manifestations of a common type. Probably the Plinian eruption of Vesuvius was similar; the Central American volcanoes have quite the same history; Krakatoa in 1883, Tarawera (New Zealand) in 1886, and Bandai San in Japan in 1888, all present phenomena identical in the main, with local variations. A slip of some sort liberated a steam column; the cause of the fracture or the source of the steam is one step too far back into theory to venture to treat it here. Release once started followed old vents, water-holes, and these vents were Soufrière and Pelée. The explosion that followed release of pressure tore away the walls of the fissure and its violence ground the material to powder. The material came from a depth where the rocks were hot, and it was heated further by friction. Those who saw the eruption of Pelée on the twentieth of May describe a black column of dust and rocks that looked like smoke with wonderful purling, interbillowing nodes that overrode each other like cauliflowers or 'brains'; this column shot up silently at first, followed by heavy detonations that finally became a continuous roar. The column was estimated by Lieutenant McCormick of the *Potomac* to be at least five miles high; he witnessed the spectacle from Fort de France. Lightning shot through the great billows in all directions in a network. When it reached its maximum height the column spread out like a flower on its stalk and the upper edges of the hard smoke-steam masses were lighted white by the rising sun. A perceptible cold wave was felt. A shower of gravel took place followed by fine dust which continued falling for an hour. This was the day of the funeral of Consul Prentis. A visit to St. Pierre later the same day showed that a terrific blast had

razed much that before had been upright, 'hot ashes were steaming at the water's edge, and there were immense bowlders lying in a bed of ashes.' These horizontal blasts are not hard to account for and do not

FIG. 16. ST. VINCENT: THE FATAL WINDWARD SLOPE OF THE SOUFRIÈRE. Leaving the horses preparatory to the ascent. The mountains in the background in clouds. June 4, 1902.

FIG. 17. ST. VINCENT: ASCENT OF THE WINDWARD SLOPE OF THE SOUFRIÈRE, showing the author and party, in a black fog, 2,700 feet up, the height of the western rim of the crater. An anxious moment. The high rim was shortly after reached, 3,200 feet up (on the right).

require a horizontal nozzle to project them. They are simply the result of the downblast after the heavy gravel has begun to fall, acting against the upblast from the throat of the volcano, and both together

deflected and thrown into terrific whirls or tornadoes by the prevailing wind, which on Mont Pelée is northeast. St. Pierre is southwest of the mountain and the crater is somewhat overturned to the westward.

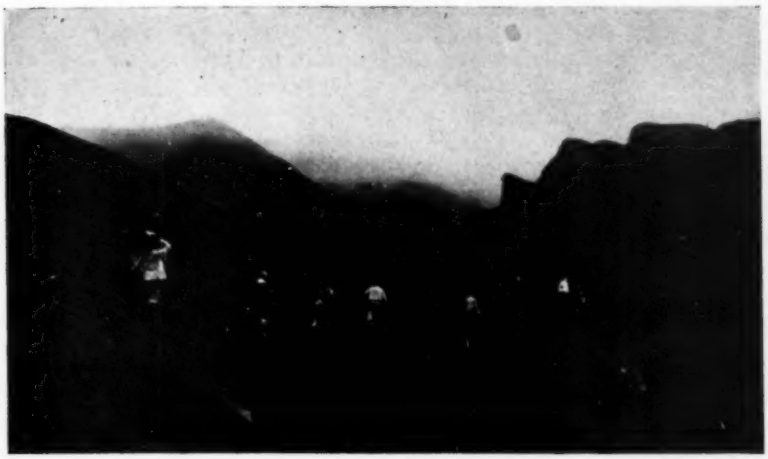


FIG. 18. ST. VINCENT: ON THE MARCH, JUST BELOW THE CLOUDS. Three of the porters have already turned back. June 4, 1902.

FIG. 19. ST. VINCENT: ASCENT OF THE WINDWARD SLOPE, June 4, 1902. In the clouds 2,000 feet up. Luncheon preparatory to the last effort. Note the increasing darkness of the four photographs: they were taken by Mr. Clare Taylor of St. Thomas, who accompanied the expedition.

The death-dealing billows of falling hot sand and gravel, *themselves a mighty downward wind,* deflecting with them the rising hot steam and

gases, finally rush down the mountain slopes in whatever directions they are guided by vale and ridge and wind. They were guided into the cliff-hollow of St. Pierre at Martinique and Walliabou at St. Vincent, both to leeward of the craters. In St. Vincent there was also an outrush symmetrical to the great crater in all directions, windward as well as leeward; hence the destruction of the windward estates. That there was tornado action is proved by the frightful demolition of masonry and the bending of trees; in St. Pierre this is away from the mountain and curving from south-southwest to southwest as we go southward from the volcano, these directions being shown by the downbent trees.

A common question is 'How were the people killed? Was it some strange gas? Were many killed by lightning?' There is no need for calling in any unusual gas; no doubt there were several gases present and the combustion of tropical vegetation made others that were highly explosive if mixed with air. This may account for some flame explosions reported as coming in from the sea-front at St. Vincent. The people of St. Pierre were killed by steam, hot dust, falling stones, falling buildings, drowning, burial alive and burning. The heat of a burning city fanned into a 'whirlwind of fire,' killed all who were left over from the other sources of death. The little city was as an ant-hill to a forest fire, in the presence of the terrible earth forces at work.

In conclusion let me say a word about the place of these eruptions in the geological history of the islands. They are not at all different from what the old cliffs, carved by the sea along the shores, show to have been the source of the heaping up of all the rocks that make the foundation stones the hills of these islands are carved upon. For these old sections are what geologists call agglomerates—masses of volcanic fragments, large and small, bedded in gravel and mud. Just such agglomerates are made anew by the great banks of dirt the volcano has vomited into the Walliabou at St. Vincent or Pelée into the gulch of the Factory Guerin. There are also old lavas interbedded with the agglomerates, showing that frequently the eruptions have been concluded in the past by the flowing out of molten incandescent rock. Perhaps this may come now, in the near future; even as I write there are cable despatches describing glowing lavas at Mont Pelée. The bared slopes of the Soufrière, devoid of vegetation, reveal a topography and geological structure so exactly like many things in our own Rocky Mountains that it is difficult to believe that one is in the tropics. There, too, in the tuff beds of the Yellowstone Park, is a fossilized tropical verdure which gives evidence that when those volcanoes of Wyoming were active, their slopes were covered by the vegetation of a warm climate near the level of the sea.

MENTAL AND MORAL HEREDITY IN ROYALTY.

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THIS inquiry into the characteristics of royalty, of which the following pages are a summary, is an attempt to solve several interesting and important questions. First, by including all modern royal families, it tries to give a fair estimate of the mental and moral status of these privileged personages as compared to the world in general. Second, it seeks to find the influences on the individual and on the breed of that environment of rank and power in which these specially elect have lived and moved. Third, by taking a great group of interrelated human beings with known pedigrees and characteristics, it seeks to throw a little light, in the nature of facts, on the old enigma—Which is the more important, environment or heredity, or do both together somewhat fail to explain all the phenomena, and must we postulate a third ultra-natural cause, working aside from biological laws, in order to account for all the varying facts of personal history and character?

It is evident that each human being has certain definite mental, moral and physical characteristics and that these are due to not more than three causes, heredity, environment and free-will. The first two are generally considered to play an important part, and the third is far from being ignored by some. It is also very evident that there is but a hundred per cent. of cause for human character, and whatever in our natures is due to one of these causes takes that much from the others. It is the chief aim of these pages, by the use of a scientific method, to get an insight, rough though it may be, into the proportionate influence played by these three factors in the make-up of mental and moral life.

The other questions touched upon are the effects of inbreeding, the relation of genius to insanity and sterility, and also the relationship between the rise of a country and the character of the blood of its kings. This last has been strikingly evident in several instances, notably Spain, Portugal and Prussia, where the prosperity of the lands have been a reflection of the ability of the rulers. Here one can trace a hidden but important cause for the condition of the country in the different combinations of ingredients of blood which have led to the individual peculiarities in the men and women who ruled over these realms and stamped their impress upon them.

The vexing question of determining in any way the proportionate average influence taken by the three possible causes in the determination of human faculties and character can probably only be solved when we possess, on the one hand, a knowledge of the circumstances in which the individuals lived, and, on the other, a complete knowledge of the characteristics of their ancestors and family to a reasonable degree of remoteness.

In many instances psychologists, historians and philosophers have observed the evident relationship between the lives and actions of men and the environment in which they lived. Even as early as Aristotle the characteristics of the Greeks were noted as midway between the Chinese and the Egyptians, and their different relations to the climate, geography, etc., were observed and reasoned upon. One of the most famous of recent names in this connection is that of Buckle, who attempted to reduce history to a science, and explain the actions of men according to natural laws. To his mind, food, climate, volcanoes and other external causes played an important part. Against Buckle stood Carlyle and many others who considered it degrading to attempt to reduce human action to mechanics; for them the great soul or 'hero' was the all-important element, and history was to be considered largely as a set of biographies of great men. Mohammed, Luther and the great kings could not be explained as a product of the times. With Carlyle must always stand the theologians who dwell upon the greatness of the human will and the divinity of the spiritual side of man, which is supposed to raise him above his trials and make him the true lord of creation.

In more recent years an attempt has been made to show that heredity is very important in producing those geniuses whose influence is so paramount in molding the lives of others. Galton and de Candolle have met with much success in this line. Thus the three factors have all had their supporters—heredity, environment and free-will—some would give preponderance to one and some to another, and no one knows which is the most important or influential.

Now, thanks to the researches of Galton, Pearson and others, the proportionate amount of hereditary influence from each parent, and from each more remote ancestor is known with considerable approximation, except as regards certain peculiar types; as when for instance the maternal and paternal stocks differ very much from each other, or for some other reason we have prepotency, as in the case of albino animals, or perhaps when new varieties make their appearance we seem to have errors from the expected.

Still the law may be considered virtually true when we deal with large averages, and thus by knowing what we ought to expect from heredity alone, we may take a large number of verified individuals

with known pedigrees, and see how closely the characters of persons correspond with what we should expect were heredity the sole cause of mental and moral peculiarities—in other words, see if the results are as certain when applied to mental traits as to the more physical and tangible qualities like eye and hair, color, stature, etc. If it should be found that the human mind and moral character are subject to the law of Galton, and with an accuracy as constant as the coloration of animals, then we may conclude that the mind and character are very strongly inherited, since coloration in animals is due to what we at present at any rate consider heredity. Of course we do not expect to find the same accuracy in dealing with psychic aspects, since every one knows that moral traits, for instance, are much the result of environment—education, example, etc. Let us, by studying human characters and comparing them with their close blood relations, see how strong inheritance appears to be.

It is often impossible to say in any individual, how much is due to one and how much to another cause, but by taking a large number we may estimate in a rough way the proportionate reliance that is to be placed on each factor on the average. Galton's law, based on stature and color in animals, in human hair and eyes, etc., is this: Each child inherits one half of his make-up from his parents, one half of the remaining half from his grandparents, one half of the remaining one fourth from his great grandparents, and so on to infinity. Thus each parent contributes one fourth of the entire influence, each grandparent one fourth of one fourth, each great grandparent one eighth of one eighth, or one sixty-fourth, and so on. So we see how little is the influence to be expected from heredity from one distinguished great grandfather.

In order to get material for such a study, one might take individuals at random and then their brothers and sisters and all their ancestors to a reasonable degree of remoteness, say all the great grandparents, which would give 87½ per cent. of the entire influence. This would be extremely difficult, as it is almost impossible to verify even the names of all the great grandparents of most people, let alone their mental and moral traits. Or one might use a large number of uncles and aunts to determine the latent inheritance of the ancestry, not known in the parents. Unless one had some proper way of selecting the material he might take instances that illustrate some theory and neglect others that do not.

The method I have employed has been to take individuals merely by blood relationship, and include every person about whom anything could be found. By doing this, I have escaped any selection of cases which illustrate a theory and at the same time know the exact blood relationship of every person to every other person. Of all families

applicable to this method the royal ones offer the most favorable field, owing to the maintenance of family trees and the great interest that has always been taken in their lives and characters as found in histories, biographies and memoirs. Besides, although all have the highest social rank, they have lived in different countries, in different centuries and under varying circumstances, with different educations and opportunities. Their peculiar positions make it unwise to compare them with men at large, but, having a great number, we can properly compare them with each other and judge them according to a standard of their own.

Galton in his 'Hereditary Genius' purposely avoided royalty, because, as he says, the qualities that make a great king are not the same as apply to genius in general. In this work it is no drawback, since here I have gone with more pains into the question of intellect and actual achievements, and a man is not given the same rank for being a wise and successful ruler that he is for great and brilliant creative achievements. The adjectives that are used by biographers and historians are the basis of the estimate, and by this standard William I. of Germany would not rank with Frederick the Great, since one does not find the same admiration expressed for his intellect.

By taking down every individual met in every degree of blood relationship and also everything in the nature of a characterization or adjective applied to him, I have been able to verify or check the estimates, and avoid the difficulty which one might expect to arise from a lack of uniformity of opinion. It is really very easy to get a sufficiently clear idea, in a rough way, of the mental and moral status of any historical character. The accounts may vary on some points but not much on essentials. Thus in the case of Frederick the Great none would question his high intellectual standing, though considerable difference of opinion would be found relative to his moral qualities, most putting him rather low. The same would apply to Napoleon, but in both these instances the interesting and important thing to be explained is the intellect, and of this we can form a sufficiently just estimate. In the same way the important fact regarding Prince Albert, consort of Queen Victoria, is his high moral tone and studious tendencies, and about these we can have no question. So that in the main, two sufficiently accurate scales can be formed in which to place them all, one for the intellectual side and one for the moral side.

Grades from 1 to 10 have been used for each class of traits, intellectual and moral; and attention has also been paid to the law of 'Deviation from an average,' by which most people are made to range close to mediocrity, the geniuses and imbeciles being relatively few. This law is set forth in Galton's 'Hereditary Genius,' page 22, and

is probably as true of mental stature as of physical, where it has been proved by actual measurements. This consideration is of great importance in proving the inherited nature of genius and stupidity, because if after placing most of our individuals in grades four, five, six and seven, and admitting only a very few to grades nine and ten, or to one and two, we still find them to be closely related to others, it is all the more a proof of heredity.

Besides this number I have been able (thanks to the 'Genealogy' of Lehr, which contains the full pedigree, male and female, to the twelfth generation, of all the northern ruling families) to extend the number to about 3,500 related persons as a field for study of genius alone.

This book contains the names of 3,312 distinct persons, but by intermarriages and repetition the actual number is raised to 32,768. It would of course be a very long undertaking to look up the characters of 3,312 persons, but by using the index and 'Lippincott's Biographical Dictionary' it was not hard to tell how many of the number are not mentioned at all, and consequently were not geniuses or worthy of grades nine or ten. It seems fair to assume that if a person was of noble rank (and there are practically none others in Lehr's 'Genealogy') and did not distinguish himself sufficiently to gain a place in a biographical dictionary as large as Lippincott's, he could not have been very great, at least as regards outward achievements, which is the standard here employed.

The standard for grades nine and ten is very high indeed. It is made up of really great names and includes few below the standard of William the Silent, Gustavus Adolphus, Peter the Great and the Great Condé, Turenne, Maurice of Nassau, and, among the women, Isabella of Castile, Maria Theresa, Elizabeth of Palatine and the Duchess de Longueville.

Of course being in Lippincott's is no criterion of mental calibre in a king, so that many who are there must be at once thrown out, as for instance Louis XIII., XV. and XVI. of France. No one is placed in grade nine or ten for intellect, unless his or her name appears in Lippincott's and also appears there in virtue of mental endowments or distinguished achievements. There are only a few, and those are actual kings, who appear in this biographical dictionary merely on account of their birth. They are easily detected and would be excluded by any one.

Occasionally I have met with a character in the histories or large biographies who seemed to me to be worthy of rank nine or ten, whose name is not to be found in Lippincott's. Such a person was Sophia 'The Philosophical Queen,' of Prussia, and grandmother of Frederick

the Great, but these have been rigorously kept out, in order to make the standard as impersonal as possible.

By starting with the present king of England and including all his ancestors to four generations, and then all the other descendants of these ancestors, all their wives and their ancestors, and stretching out in every direction by this endless chain method, taking every one about whom enough could be found to be satisfactory, I have at present obtained mental and moral descriptions of 633 interrelated individuals, including pretty completely the following countries of Europe: England (House of Hanover), France, Prussia, Brunswick, Hesse-Cassel, Holstein, Saxe-Coburg, Russia, Sweden, Denmark, Spain, Portugal, Savoy, Italy, Austria and the Netherlands. The period covered extends in general back to about the sixteenth century, but in the case of Spain and Portugal to the eleventh century.

Let us take up the countries separately and study the quality of the blood introduced into the royal families and its relation to the character of the subsequent breed and to the history of the land itself.

I. *Evidence from House of Hanover in England.*

George I. was a rather weak, dull and indifferent scion of a gifted stock. He was descended from the brilliant House of Orange, which we shall afterwards see was able to form the greatness of the Hohenzollerns in Prussia, but he himself was nothing. From his time to the present the following unions have been made with the results of introducing the following stocks:

Brunswick, stock pretty good, no genius.

George II.=Brandenburg, stock good, no genius.*

Frederick Prince of Wales=Augusta of Saxe-Coburg, stock good, no genius.

George III.=Charlotte of Mecklenburg, stock 'obscure,' good, no genius.

Edward Duke of Kent=Victoria Maria Louisa, of Saxe-Coburg, stock excellent, no genius, strong literary bent.

Queen Victoria=Albert of Saxe-Coburg, stock excellent, no genius, strong literary bent.

Edward VII.=Alexandria of Denmark, stock excellent, no genius.

Thus from George the First's time on, there has never been any genius introduced into the pedigree of the House of Hanover, and, as we all know, none has appeared in any of the descendants bearing the name. So as regards high mental attainments, we have what we might expect, dullness the characteristic, with here and there fairly good

* No genius means that no individuals worthy of grade 9 or 10 for intellect are to be found.

minds. There is certainly nothing higher than grade eight (that of Queen Caroline, Consort of George II.)

There have never been a large percentage deficient on the moral side, and we find the pedigree upholding this, for compared with the Bourbon-Hapsburgs and Romanofs, the families that have allied themselves to the ruling house of England have been remarkably good. Quiet, domestic and religious traits have been the characteristics of the various female lines and since the direct progenitors, George III. and Edward of Kent, have had the same, such have been the later characteristics of most of the members of the English house. These moral qualities are perfectly in line with heredity but might be also explained by environment, either home influence or public opinion changing with the centuries.

But if we adopt the environment view, we can not rightly explain the bad characters as they appear, nor the contrasts that often mark the children. There have not been any very depraved since George IV. He and his brother, the Duke of York, were silly, dissipated men without ambition or serious purpose; William IV., another brother, was not much better. Their father and mother, George III. and Charlotte, were as unlike them as could be, painfully punctilious in their daily lives, so domestic and quiet as to be a subject of satire on this account.

But George III. had eleven children who have left records. Of these, three were the only black sheep. Why was this? Because all the others represent the majority of hereditary influence and turn out well. George IV. and the Duke of York revert to their grandfather, Frederick Prince of Wales, and are just like him. William IV., in his eccentricity, subbornness, simple ways and feeble mind, resembled his father, George III. His vices, if due to heredity, came from further back. In the generation before this (brothers and sisters of George III.), there were two in six who were very immoral. These were Edward, Duke of York,* and Henry, Duke of Cumberland.†

This percentage of one third is not as high as called for by heredity, since both Frederick, Prince of Wales, and his consort, Augusta, were rather immoral, which should call for fifty per cent., and to this should be added the slight amount of influence from such characters further back.

The generation before this contains seven children of George II. and Queen Caroline: × Frederick, 3, 3;‡ × William, 6, 3; Anne, 4, 4;

* Doran, 'Queens of Hanover,' p. 406.

† Jesse, 'George III.,' Vol. II., p. 2.

‡ 3, 3 means grade 3 for intellect, 3 for the moral side.
6, 3 means grade 6 for intellect, 3 for the moral side.
The mark × is placed before those who may be considered 'bad' and is applied to those below grade 4.

Louisa, 4, 9; Amelia, 5, 6; Mary, 4, 8, and Caroline Elizabeth, 4, 9. Both sons were below the average morally, the others range pretty close to the average, except Caroline Elizabeth, who was an exceptionally lovely character.* These are not out of line with heredity. The generation before this contains only George II. and his sister, who became queen of Prussia. She was a mediocrity, and George II. represented the bad side of the family inheritance.

George I. was a poor representative of an illustrious stock as his mother was the intellectual Sophia, Duchess of Brunswick, a descendant of the great House of Orange on both sides. It was left for the sister of George, who was the 'Philosophical Queen' of Frederick I., of Prussia, to transmit the genius of Orange into Prussia to the generation of Frederick the Great. It can easily be seen that after the two first Georges, each the poorest among his kind, that the ancient greatness must necessarily die out, as it was never rejuvenated in this house.

To summarize the House of Hanover: It contains 28 persons whose pedigrees have been studied. The total number brought together on a chart containing in addition the full pedigree for George IV. to five generations is 87. Of these 87 only two show high intellectual variation; these are Sophia, Duchess of Brunswick (10) and Caroline of Brandenburg (8). It was shown that these higher streaks were lost by selection. There are only five as low as grade 3 and one in grade 2. Thus the house of Hanover has never deviated much from the average, either in itself or in the nature of the blood introduced, and the characters are much as one would expect from heredity alone. It is a great mistake to consider that Queen Victoria had a bad ancestry. On the other hand, it was in general very good. The ancestry of King Edward VII. is even better and most of Victoria's children have upheld the standard.

Saxe-Coburg the Reigning House of England.

As I started with the present King of England, and since his father was a prince of Saxe-Coburg, I was at once led into that family, which will now be considered.

Albert, the lamented consort of Queen Victoria, was, as every one knows, a highly cultivated, earnest and noble man, a devoted husband and an enthusiastic reformer in all affairs related to the public good. Well versed in science and literature, he was also an accomplished musician. Did he come by this character through inheritance? It will be seen that characters of this sort are written all over his family pedigree. As the group, just considered, Hanover was remarkable for its dullness, so this group is remarkable for its virtue and bent towards literature, science and art. It is not that the dukes in the male line

* Wharton, 'Wits and Beaux,' p. 177.

have shown such tendency in a marked degree, but it is that at each step going back, the pedigree is what we should expect.

There are 118 individuals in this group, which may be considered as a region of the entire chart. It will be seen, by referring to a chart of this house, that the main tap roots of this stock have been from Ernst, the Pious, Brunswick Wölfenbruttel, Saxe-Coburg, Saxe-Sallfeld, and other branches of the Saxe houses. Ernst 'The Pious,' himself, who appears many times in the pedigree, was a man of wisdom, virtue and marked religious bent; the Brunswick family was noted for its strong literary taste, as will be shown more in detail later, and all marriages with the Saxe houses can be seen to have kept alive those same qualities as the salient characteristics of the breed.

We see that after two hundred and fifty years, the same traits exist because there has never been a time when blood of another sort was introduced to contaminate or dilute it. Everywhere we notice that love of ideas and refinement of taste have been the object sought after, rather than the sway of power or the obtainance of military fame. There has not been one soldier of sufficient renown to appear in any of the smaller biographical dictionaries like Lippincott's or Rose's. One only was what may be called a successful general, but his career is described solely in the larger German dictionary.

From Ernst, the Pious (1601–1675), to Frederick IV. (1774–1793) the branch of Gotha contains 64 names. The branch of Coburg from John Ernst (sixteenth century) to Albert, consort of Queen Victoria (1819–1861) contains 118 names. There is considerable intermarriage, so that we find some persons repeated several times. Thus the actual number of individuals is less than this, still the value scientifically is 64 + 118 or 182. Although in the furthest degree of remoteness we deal with sixty-four different tap roots, owing to intermarriages there are only twenty-one family names. Among these sixty-four, we find the following families composing the stock:

Saxe (different branches) twenty-one times. That is, the breed was perpetuated to the extent of about a third from itself. We find the name of Brunswick seven times, Mecklenburg six, Anhalt five, Holstein four, Hesse three, Reuss two, Solms two, Schwartzburg two, Baden, Bentheim, Castell, Erbach, Hohenlohe, Logwenstein, Cetlinger, Sayn, Stolberg, Waldeck and Zinzendorf each one. Among all these 182 related persons, there is not a single genius or individual worthy of grade 9 or 10 for intellect. The only two in 8 are Ernst II., of Gotha (died in 1801), who was a distinguished astronomer, and Louis Dorothea of Saxe-Meiningen (8) who corresponded with Voltaire, and was called the 'German Minerva.' She was the mother of Ernst II., the astronomer. Also there is not a fool, imbecile or moral degenerate among them all as far as is known.

From Ernst, the Pious, on, selection was constantly made of men and women of his own type, so that sound judgment, high moral qualities and strong literary taste are continually reappearing and were never lost even after nine generations. There were among this group of 182 (counting a person every time he occurs) no less than eighteen who were authors or had strong literary tastes. In the most remote generation we find five in thirty-two, in the next three in sixteen, in the next one in eight, in the next two in four, in the next two in two and in the next two in two; the remaining three occur in the more recent part of the chart, and are even more closely related. Thus we see Ernst, 'The Pious,' and Augustus of Brunswick, who were both literary, perpetuated down the line in this family by the force of intermarriage and selection.

The intellectual average is everywhere near the mean or slightly above, and the moral average is everywhere near the mean or very much above it. There being not a single bad character introduced into the blood directly, the children apparently could not turn out badly. It is the cleanest and best pedigree to be found in any royalty, and its influence on European history has come to be very great, since its very merits have entitled it to several thrones. In fact it can be shown that no royal family has been able to maintain itself without degenerations, unless it has taken a good share of Saxe-Coburg blood. The good qualities, if due to heredity at all, in Austria, England, Germany, Belgium and Greece are largely due to it. It probably saved the Bourbons in Portugal.

Thus in tracing the pedigree and accounting for the virtues of Albert, Consort of Queen Victoria, we find the theory of mental and moral heredity sufficiently sustained in *his* case, as well as in the others. At least five of the close relations of the Consort may be considered as almost exact repetitions of his charater. These are his grandfather, Franz Frederick Anthony, his two uncles, Ferdinand and Leopold I., King of Belgium, his brother, Ernst, and cousin, Ferdinand of Portugal.

The family of Saxe-Coburg and Gotha shows by its 118 members here represented that the assumption of high rank and power and the consequent opportunities for ease and luxury do not in the least tend to degeneracy of the race when the good qualities are kept up by marriages with stocks of equal value and no vicious elements are introduced into the breed. A parallel to this is found among the kings of Portugal during its days of supremacy, where for twelve generations nearly every sovereign had all the wisdom and strength required of a ruler.

(To be continued.)

SCIENTIFIC LITERATURE.

PHYSIOLOGICAL CHEMISTRY.

THE publication, by an American author, of another new work devoted exclusively to physiological chemistry gives evidence of the increasing recognition which this branch of science is receiving in this country. The 'Text-book of Physiological Chemistry,' by Dr. Charles E. Simon,'* of Baltimore, is a satisfactory addition to the few really valuable books on this subject in English. Resembling in many details of treatment the widely known volume by Hammarsten, Simon's new treatise shows the same features of presentation which have made the author's work on Clinical Diagnosis so favorably received. In somewhat over 400 pages the chief facts and important methods of physiological chemistry are offered in the light of the recent advances, the purely chemical aspects being emphasized.—A new English translation (470 pp.) of Bunge's 'Text-book of Physiological and Pathological Chemistry'† is announced by American publishers. The new edition of this work which has lately appeared in German as the second volume of Bunge's new 'Lehrbuch der Physiologie'‡ shows the same unique peculiarities of style which make his publications so readable. Bunge's views on many topics seem, however, somewhat extreme; they frequently attract attention from the unusual standpoints assumed, rather than from any indication of broad and progressive familiarity with the literature of the subject.—The 'Lectures on Chemical Pathology' by Dr. C. A. Herter,* of New York, forms one of the most suggestive and interesting publications of the year. They point out the importance of chemical considerations in the study of both physiological and pathological processes, and abound in illustrations drawn from an extensive acquaintance with clinical and experimental data. The medical practitioner who has lately been hearing about physical factors in therapeutics will find in Dr. Herter's chemical treatment much that is new and stimulating. The distinctive scientific attitude of the author is everywhere apparent.—Oppenheimer's 'Die Fermente und ihre Wirkungen,'† which appeared two years ago, is now available in English form under the title 'Ferments and their Actions.'‡ The extensive references to the literature make it helpful to the physiological chemist. Dr. Effront's work on enzymes has also been translated (in part) from the French by Dr. Prescott, of the Massachusetts Institute of Technology.§—In the book of 290 pages on 'Les fonctions hépatiques,'‖ Gilbert and Carnot have reviewed the physiology of the liver in its various aspects. Like Hédon's publication on the pancreas, it indicates a return to the monograph form of presenting the details of physiological research.

* Lea Brothers and Co., Philadelphia and New York.
† P. Blakiston's Son and Co., Philadelphia.
‡ F. C. W. Vogel, Leipzig.

* Lea Brothers and Co., Philadelphia and New York.
† F. C. W. Vogel, Leipzig.
‡ Griffin, London.
§ John Wiley and Son, New York.
‖ C. Naud, Paris.

THE PROGRESS OF SCIENCE.

THE PITTSBURGH MEETING OF THE AMERICAN ASSOCIATION.

THE American Association for the Advancement of Science held its fifty-first annual meeting at Pittsburgh on the last day of June and the first three days of July. There was a registration of 435 members, and some 350 addresses and papers were presented before the several sections and affiliated societies. As the number of papers so nearly equaled the number of members, it is evident that those present were chiefly working men of science. It must also be remembered that some members of the affiliated societies are not members of the Association, so that the gathering of scientific men numbered about 600. They were almost entirely different from the 300 students of the natural sciences who met in Chicago last winter. At the next meeting of the Association to be held in Washington during convocation week, the two groups will come together, and the meeting will probably exceed in size and importance any similar congress of scientific men held outside of Germany.

The address of the retiring president of the Association, Dr. Minot, of the Harvard Medical School, is printed above. Though admirably expressed and on a topic that should be of general interest, it must be confessed that the relations of consciousness to organic evolution and the material world is a subject outside the range of the consciousness of the ordinary man. The addresses of the vice-presidents maintained a high scientific standard, but were in most cases addressed to specialists, whereas it seems that there should be at the meetings of the Association some addresses and discussions that appeal to all scientific men and to those who take an intelligent interest in science. Of this character were the interesting evening addresses by Professor D. S. Kellicott and Dr. Robert T. Hill, but otherwise the programs were addressed to specialists. Indeed the sectional meetings tend to be too special even for the specialists. Some method should be adopted for the presentation of scientific papers that will make attendance more interesting and profitable. A distinction should be made between small groups of men interested in a common topic and larger numbers who even within the limits of their own science should not be expected to listen to papers that they would not read. Several amendments to the constitution were adopted tending to strengthen the organization of the sections and the permanence of administration. The council will hereafter elect each year three members at large who will doubtless add to the efficiency of that body, and the sectional committees will become more nearly sub-councils, while the term of office of the secretaries is extended from one to five years. The membership of the Association has considerably increased during the year, being now about 3,500, and the finances are in excellent condition, the permanent secretary, Dr. Howard, having handed over $2,000 from current income to the permanent fund.

Professor Asaph Hall is succeeded in the presidency by Dr. Ira Remsen, the eminent chemist, president of the Johns Hopkins University. The vice-presidents are, for mathematics and astronomy, Professor George Bruce Halsted, of the University of Texas; for physics, Professor E. F. Nichols, of

Dartmouth College; for chemistry, Professor Charles Baskerville, of the University of North Carolina; for mechanical science and engineering, Professor C. A Waldo, of Purdue University; for geology and geography, Professor W. M. Davis, of Harvard University; for zoology, Professor Charles W. Hargitt, of Syracuse University; for botany, Dr. F. V. Coville, of the U. S. Department of Agriculture; for anthropology, Dr. G. M. Dorsey, of the Field Columbian Museum, Chicago; for social and economic science, H. T. Newcomb, of Philadelphia, and for physiology and experimental medicine, Professor W. H. Welch, of the Johns Hopkins University.

FUNDS FOR THE PROMOTION OF RESEARCH.

THE appropriations for research made by the American Association are very small compared with those of the British and French Associations. The British Association has a large income from local members, who pay fees for the meeting, and the French Association has a large endowment which is continually increased by bequests; each of these associations appropriates about $5,000 annually for research. The permanent funds of the American Association are slowly increasing, chiefly by savings from income, and now amount to about $12,500. The income from this fund, however, only permitted making at Pittsburgh five small grants, $75 each to committees on blind vertebrates, on the relation of plants to climate and on the velocity of light, and $50 each to committees on anthropometry and on the atomic weight of thorium.

It was announced at a general meeting of the Association that the Botanical Society of America has set aside the sum of $500 from its yearly income, this year and every succeeding year, to be used in making grants in aid of investigations. The funds of the Botanical Society consist of the accumulated dues and interest paid in by the members, and the grants in question probably constitute the only series ever offered in America, the money for which has been contributed wholly by a body of scientific workers. Should the members of the American Association be equally self-sacrificing there would be available an annual income of $35,000 for research. It must, however, be said that the more important demands for funds for research are pretty well met. The National Academy administers funds large enough to meet all pressing needs, the Elizabeth Thompson Science Fund has a fair income at its disposal, and all other funds are of course overshadowed by the great endowment of the Carnegie Institution. Some disappointment was expressed at Pittsburgh that no officers of the Carnegie Institution were present, and that the plans of the institution have not been more freely made public. But it is certainly the part of wisdom for those responsible for the conduct of the institution to take ample time before coming to any final decision. Ample opportunity for public discussion will doubtless be afforded before the institution commits itself to any definite policy.

NATIONAL LEGISLATION.

THE government of a nation is becoming increasingly a problem of applied science. Opinion and the rule of thumb are gradually being superseded by knowledge and the direction of the trained expert. This is clearly shown by the more important measures passed by the recent congress. The destructive activities of warfare are becoming less important than the commissariat and the medical department; but they rest equally on the applications of science. This is indicated by the usual superiority of the navy over the army, and by the place in the army taken by West Point graduates as compared with the amateur volunteer. Fortunately war is no longer the chief busi-

ness of a nation; our present duty in the Philippines is pacification rather than warfare, and in arranging a civil government, Congress has been largely concerned with questions of applied science. The matter next in general interest before Congress was the isthmian canal, where legislation has been definitely based on the report of a committee of experts. Nearly of equal importance was the subject of irrigation, where the law enacted and its execution depend entirely on scientific advance. So other important measures, such as the establishment of a permanent census bureau, and a large part of the routine conduct of the business of the nation, may be regarded as direct applications of science. It is interesting to note that questions which belong to the more backward political and social sciences did not fare as well as those resting on the natural and exact sciences. There was less agreement as to tariff, subsidies, franchise, currency, etc., and legislation concerning these questions was mostly dropped as postponed. It seems curious that when legislative and executive work depend so largely on science so few men of scientific training should be found in Congress or in the Cabinet. The retiring prime minister of the British Empire has been president of the British Association for the Advancement of Science, and it is said that he retires to engage in scientific work; his successor is the author of books in which the fundamental problems of science are treated. In France men of science have taken an active part in government. Here, where the government is more dependent on science than in any other nation, there can scarcely be found a single scientific man in any elective position. Perhaps it is just as well under existing conditions that men of science should not be politicians. We have, however, in fact four main branches of the government—the executive, the legislative, the judiciary and the scientific; and there is reason to suppose that the expert or scientific department may at some time be recognized as coordinate with the others.

AN UNFORTUNATE TRANSLATION.

A TRANSLATION of Laplace's 'Philosophical Essay on Probabilities'* has been issued by Messrs. Wiley and Sons, this being its first appearance, as far as we know, in English. No algebra is used in this essay, its aim being to present the fundamental principles and the general results of the theory of probability in a simple and popular manner. This aim is attained in some portions, especially in those relating to judicial decisions, elections, insurance statistics and annuities. Other discussions, particularly those treating of the adjustment of observations and Laplace's method of generating functions, are not clear. In fact the last-mentioned subject is so obscurely presented that Todhunter in his 'History of Probability' characterizes it as a waste of space, while Langsdorf's German translation devotes eight pages of notes to its elucidation. The present translation, however, has no notes, and the obscurities of the original are often rendered darker yet by renderings into imperfect English.

The work of translation has been done by F. W. Truscott and F. L. Emory, of the West Virginia University, the former being professor of Germanic languages and the latter professor of mechanics and applied mathematics. A combination of this kind should produce the best results, for the competent linguist will see that idiomatic English is used, while

* 'A Philosophical Essay on Probabilities,' by Pierre Simon, Marquis de Laplace. Translated from the Sixth French Edition by Frederick Wilson Truscott, Ph.D. (Harv.), and Frederick Lincoln Emory, M.E. (Wor. Poly. Inst.). New York, John Wiley & Sons. 1902. Duodecimo, cloth, 196 pages. Price, $2.00.

the competent specialist will see that the correct technical terms are employed and that explanatory foot-notes are given in all doubtful cases. Here, however, the French word that means addition is sometimes rendered as 'unite' and the word that means subtraction is rendered 'draw from.' What is the meaning of such expressions as 'manner of relating past events with the probability of causes,' 'to conclude the order of preference,' 'diminution of subsistences,' etc.? We are told that stars are 'called double, on account of their conjunction' and that 'laws are the ratios which connect particular phenomena together.' The strange expression 'salubrity of the sun' only ceases to be puzzling upon reference to the original, where we learn that *sol* is the word which the translators suppose to mean 'sun.' On one page 'primary number' is used six times where prime number should have been employed. Expectation is a common term in the theory of probability, but the translators prefer the word 'hope.' DeMoivre is a name well known to American mathematicians but the translators call him 'Moivre,' as Laplace properly did. For the same reason, no doubt, Pliny appears as 'Pline,' but it is hard to understand what reason or fact justifies the statement that 'the duration of the rotation of Saturn is 0.427 minutes.'

In the concluding paragraph of the essay occurs the well-known statement of Laplace that the theory of probability is really only common sense reduced to calculation. The translators, however, calmly tell us that 'the theory of probabilities is at bottom only common sense reduced to calculus.' Alas, that American scholarship and American science should have fall upon them the blot of such poor work. No doubt, the translators put forth this book, really believing it to be a creditable production; they honestly think that they are good linguists and that they have a good knowledge of the subject matter of Laplace's essay. Such a state of mind can only be due, we think, to grave defects in the methods of instruction in the schools and colleges where these men were educated, methods not worse probably than those in many others. Lastly, what shall be said of publishers who issue such crude material and thereby bring disgrace upon American scientific literature! Here was an opportunity where both translators and publishers might have won credit and advanced mathematical learning, for a good translation of this essay, well annotated, would furnish excellent collateral reading to many students of probability and least squares. Nathaniel Bowditch honored himself and American science by his magnificent translation of Laplace's 'Mécanique céleste,' and thereby astronomical learning was advanced in all lands. The translation of this essay on probabilities, however, brings no credit to any one, but much disgrace to many, and the only possible reparation that the publishers can make is to immediately withdraw the book from the market.

SCIENTIFIC ITEMS.

WE note with regret the deaths of Dr. John Daniel Runkle, professor of mathematics at the Massachusetts Institute of Technology since its foundation and president from 1870 to 1878; of Professor J. B. Johnson, dean of the College of Engineering of the University of Wisconsin; and of M. Hervé Faye, the eminent French astronomer.

THE coronation honors in Great Britain have been announced, in spite of the postponement of the coronation. A new order of merit has been established which includes in its list of twelve original members the names of four distinguished men of science, namely, Lord Rayleigh, Lord Kelvin, Lord Lister and Sir William Huggins. Among those who have been knighted

are the physicists, Principal Rücker, of the University of London, and Principal Lodge, of the University of Liverpool; the chemist, Professor Ramsay; the engineer, Dr. Thornycroft, and a number of prominent physicians.

THE Albert medal of the London Society of Arts has for the present year been awarded to Professor Alexander Graham Bell, for his invention of the telephone.—The eminent astronomer, Professor Giovanni Schiaparelli, has been elected an associate of the French Academy of Sciences, and M. Amagat a member of the section of physics.—The Academy of Sciences of Vienna has elected Lord Rayleigh a corresponding member.

PRESIDENT ELIOT, of Harvard University, was elected president of the National Educational Association at the recent Minneapolis meeting.—Dr. William H. Forwood has succeeded Dr. George M. Sternberg as surgeon-general of the army.—Professor Edward S. Holden has accepted the appointment of librarian of the Military Academy at West Point.

MR. F. H. NEWELL, chief hydrographer of the U. S. Geological Survey, has gone to the West to supervise surveys in connection with the work in irrigation authorized by Congress. Surveying parties are in the field in California, Oregon, Washington, Montana, Utah, Nevada, Idaho, Arizona and Colorado.—The American Museum of Natural History, New York city, has sent an expedition to eastern Colorado to examine the unexplored portions of the Protohippus Beds in the hope of securing a complete skeleton of this animal. At the same time search will be made in western Nebraska for the same fossil species of horse, in the locality where Professor Leidy first discovered it. The expenses of these expeditions are defrayed by the gift of Mr. William C. Whitney.—The *Windward* is being fitted for its fifth and last trip and will soon sail via Etah for Cape Sabine on Smith Sound, where it is expected that Lieutenant Peary will be found.

IN honor of the late Alpheus Hyatt a memorial fund is being collected for field lessons in natural history. Professor Hyatt was greatly interested in extending the teaching of natural history to the schools, and this memorial appears to be especially appropriate. While the fund will be administered by a board of trustees at Boston, contributions from Professor Hyatt's former pupils or friends, wherever living, will be welcome. The treasurer, to whom subscriptions may be sent, is Mr. Stephen H. Williams, 2 Tremont Street, Boston.—Dr. Joseph Leidy, Jr., 1319 Locust Street, Philadelphia, is collecting the correspondence of the late Professor Joseph Leidy for publication. He would be glad to possess copies or the originals of any letters of interest that may be in the possession of readers of the POPULAR SCIENCE MONTHLY.